MA

military automation

SYSTEMS AND COMPONENTS FOR MILITARY ELECTRONICS • INSTRUMENTATION • AUTOMATION

JANUARY-FEBRUARY 1957

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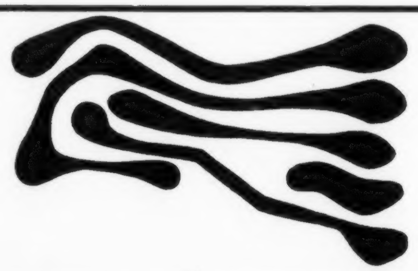
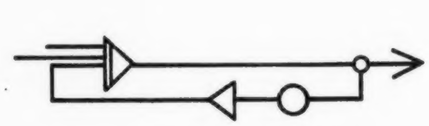
DIGITAL TECHNIQUES

The "modern" way to measure, count, compute, and control no longer is based on the number 10—but rather on the number 2 ....Page 22



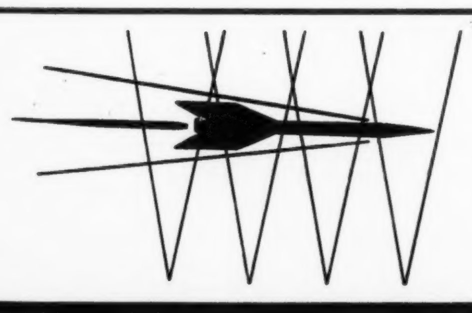
PRINTED CIRCUITRY

Printed wiring and printed circuits are changing the basic character of modern electronic circuits ....Page 34



ANALOG COMPUTERS

It is possible today to fly an airplane, drive a tank, aim a gun, or track a missile without building the plane, tank, gun or missile ....Page 26



AEROBALLISTICS

NOTS Aeroballistics Laboratory features ballistic photography, remote centralized control, and complete monitoring of 30 stations ....Page 14

INSTRUMENTS PUBLISHING COMPANY · PITTSBURGH 12, PA.

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In Our First Issue . . .

To begin a long and mutually pleasant acquaintance, we have a short biography of our editor, Commander Morrison, and his statement on the Mission of MILITARY AUTOMATION. We also proudly share with you a letter of best wishes from the Secretary of the Army, the Honorable Wilber M. Brucker.

This issue begins three important educational serial articles. They are "Printed Circuitry," "Modern Digital Techniques," and "The Analog Computer." As these topics are developed in this and following issues, we expect them to provide an outline of the *new techniques* which are radically altering the design, operation, and use of military equipment and systems.

Note that your editorial content in this publication is much more than just "news"—it is designed to cover the basic principles on which modern automation systems are based. In future issues these principles will be put to work in many specific equipments—data handlers, computers, etc.

The fourth feature, complete in this issue, is an account of the ingenuous instrumentation used in the Ballistics Laboratory, Naval Ordnance Test Station, China Lake, California, designed to photograph a missile in supersonic flight, and automatically check and countercheck all circuits to prevent premature triggering of the missile or photographic failures.

This issue also features a brief biography of a military leader in one field of automation, Captain Alden C. Packard, USN, Director of the Aeronautical Electronics and Electrical Laboratory, NADC, Johnsville, Pa.

Featurettes for this issue include: a Doppler Navigational Radar, an extra-high-speed Motion Analysis Camera, a practical method of "stockpiling" Defense Plants, a supersonic wind tunnel Data Readout system, a clutter-operated Anti-clutter Radar Circuit, an automatic Diesel power-supply for SAGE radar stations, and a description of the AEEL, Naval Air Development Center, Johnsville, Pa. A Navigational Control System for jets opens our New Products section, which brings you concise reviews of 52 new products of interest to the military. These, plus the basic techniques in the feature articles, are chosen to sample the wide field of MILITARY AUTOMATION.

Other regular departments in this issue include: New Literature and "LitBits" providing a survey of current commercial brochures; News; and Trends. All commercial publicity items will be keyed for easy marking of your postage-free inquiry card, included in each issue. Just circle the number if you want more data on any products or services mentioned in the editorial or advertising columns, and drop the card in your mail box. It will be delivered, automatically, to our Remington Rand machines. These machines will automatically speed your request to its proper destination, and, within a few days, you will have the data you need. This also is automation.—Ed.

MA

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JAN.-FEB. 1957

Editorial

Feature Articles

Regular Features

Featurettes

Military Automation

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Commander C. O. MORRISON Named Editor

COMMANDER Claude Morrison of the Pacific Reserve Fleet, Treasure Island, California, has accepted appointment as Editor of the new national publication *MILITARY AUTOMATION*.

Commander Morrison has served in uniform as Head of the Electronics Section, Training Manuals Division, Naval Training Publications Center, Washington, D. C.; as Commanding Officer, Naval Unit, Chemical Corps School, Fort McLellan, Alabama; as Executive Officer of the amphibious attack cargo ship, USS RANKIN; as Assistant Logistics Officer for Electronics for the Commander, Pacific Reserve Fleet, Treasure Island, California (his present position).

His wartime service includes duty as Radar Material Officer on the USS HORNET (CV-8). After the sinking of the HORNET, Morrison was retained in the South Pacific as airborne radar officer under Admiral Marc Mitscher, whereby he coordinated airborne radar maintainance for Army, Navy, Marine and Australian airforces on the Russel Islands, Guadalcanal and Tulagi.

In February, 1944 he was assigned to the Electronics Section, Quality Control Division, Training Activity, Bureau of Naval Personnel. For eight months he was assigned to the Office of Chief of Naval Operations, in charge of allocations of electronic equipment for Naval Training, including the then-new techniques of radar training via simulation. His final wartime duty was as Airborne Electronics Officer on the USS F. D. ROOSEVELT, then in pre-commissioned status.

Morrison attended Simpson College, Indianola, Iowa, and the University of Nebraska, and has a Master's Degree in Adult Education. He has been Electrical Trades Teacher at the Lincoln, Nebraska High School.

He has administered naval training courses in atomic, biological and chemical warfare, and has supervised text books for Naval training in basic electronics, communications, radar, sonar, fire control, and others. Commander and Mrs. Morrison have two sons—Don, a chemical engineer with Shell Refinery at Martinez and Vincent, wind tunnel engineer with Lockheed Aircraft. Their daughter Marguerite is an occupational therapist.

Soon to appear in *MILITARY AUTOMATION . . .*

A significant development in the recruiting and training of engineers for military research programs.

Selected Military Electronic Circuits.

Applications of automation to problems of humidity control and cathodic protection in ships of the Reserve Fleet.

Operating tests of installed electronic systems in ships.

A survey of the electronic and technical training courses offered in the Armed Forces Reserve Organizations.

High-temperature electronic component developments.

The Defense Department Cataloging and Standardization Programs as applied to electronic components and equipment.

Amendments and revisions to Military Specifications in the field of military automation.

Various systems of aircraft navigation and control, surveyed and related to the Five Year Plan for development of the Federal Airway Control System.

Surveys in the fields of Military Sonar, Radar, Communications, Guided Missiles, and Infrared applications.

Articles on waveguide transmission, traveling wave tube applications, digital computers, analog computers, printed circuits, synchros, transistors, atomic power, weapons systems analysis, radio interference elimination and Xerography.

Developments in reliability studies and quality control; model basin, windtunnel and test-range instrumentation; automatic readout to digital computers; new display tube techniques.

New products, new literature, and news concerning persons of military experience now in industry and education.

If you approve—or disapprove—of our treatment of any subject, we will appreciate your thoughts. In short—we hope our "Letters to the Editor" department will grow.

To Our Military Readers:

We recognize that many military personnel now assigned in billets where they are responsible for administration or decisions involving electronic maintenance, design or logistics, may be, within a few months or years, reassigned to a different billet. With this in mind, we have encouraged military commands to supply us with addresses by key electronics billets, with the expectation that each copy would reach a number of interested readers.

However, now that you have seen your first issue, and have noted the number of basic articles we are running—many of them in serial form—*you* may want your own MILITARY AUTOMATION file for future reference and study rather than relying on your turn with the routed office copy. If you are personally interested in this rapidly developing field, we suggest that you fill out the application blank on the inside back cover and mail it in. A few extra copies of this issue were printed for those of you who want your own complete file. (Oh yes, tell your civilian engineer and technician friends that their requests are also welcome.)

Claude O. Morrison, Editor

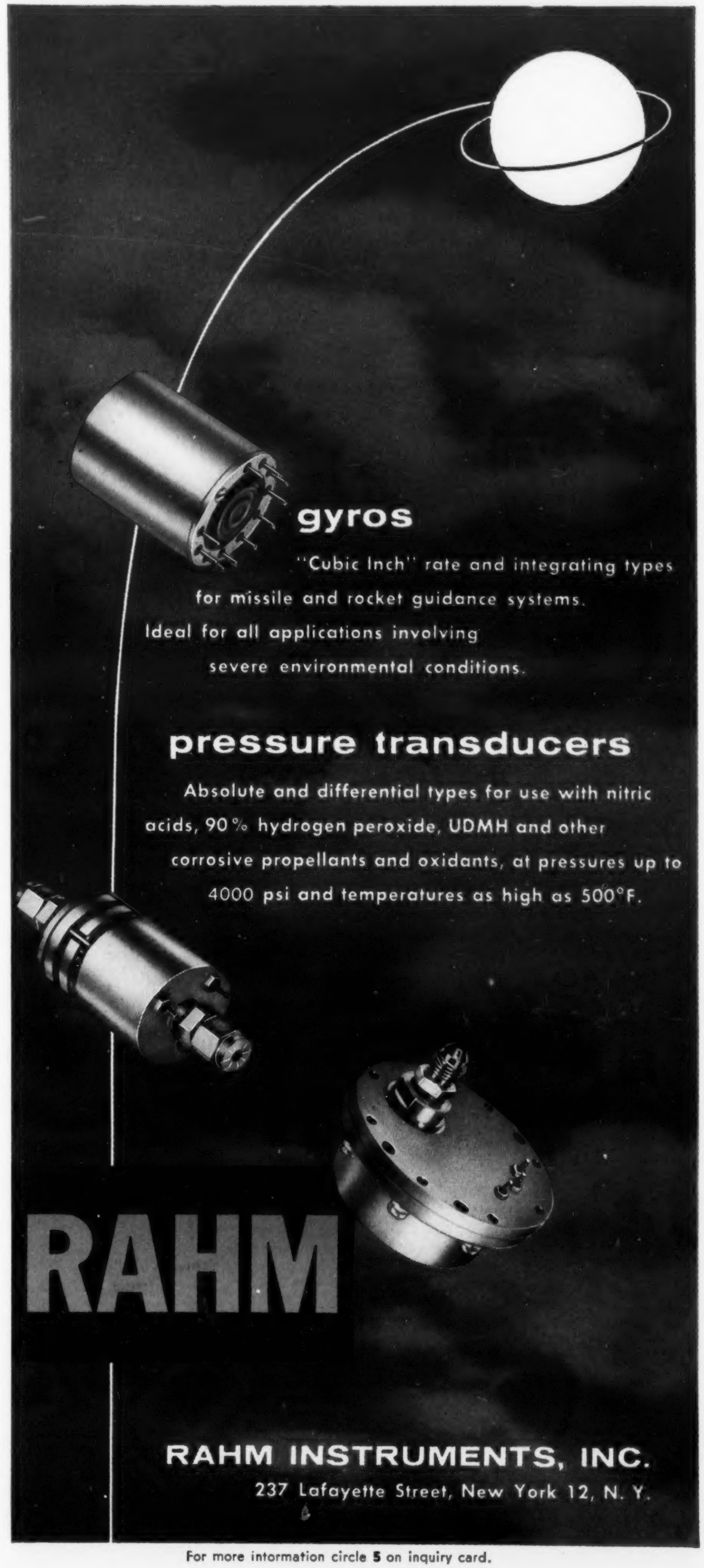
Your editorial staff is pleased and proud to share this letter of best wishes from The Honorable WILBER M. BRUCKER, SECRETARY OF THE ARMY, with all our readers and advertisers.

SECRETARY OF THE ARMY
WASHINGTON

Today's Army relies increasingly on electronic automation. It is, indeed, playing a most vital role in the Department of the Army's personnel and logistics management program. Automatic data processing offers inherent advantages over present data processing methods. This results in improved quality, quantity, and timeliness of information required for military management actions.

Any publication designed to disseminate knowledge and intensify interest in the automation field aids in contributing to the accomplishment of "Our Army's" mission. As MILITARY AUTOMATION is launched, the Army sends every good wish for its continued success.

Wilber M. Brucker
Wilber M. Brucker
Secretary of the Army



MA Contracts

KOLLSMAN INSTRUMENT CORPORATION, Elmhurst, N. Y., has a $26-million contract for production of a new and revolutionary Automatic Astro Compass developed for the Air Research and Development Command, USAF.

GENERAL PRECISION LABORATORY announces a $17-million contract from Air Materiel Command, Wright-Patterson Air Force Base, Ohio, for additional AN/APN-81 and AN/APN-89 Doppler navigation systems (story on page 40).

TEMCO AIRCRAFT CORP., Dallas, is named prime contractor by the Bureau of Aeronautics of the U. S. Navy for design and development of a new guided-missile weapons system for approximately $16 million.

FORD INSTRUMENT CO., Div. of Sperry Rand Corp., has a contract in excess of $15 million from the Air Force for production of a new all-weather navigation system (ASN-7) that continuously and automatically tells a pilot where he is, the direction he should fly and distance to his destination.

GOVERNMENT DIVISION of Allen B. DuMont Laboratories, Inc., has a $1,400,000 subcontract from the Military Products Division of International Business Machines Corp. for precise electronic equipment for use with a new and improved navigation and bombing system for military aircraft.

MILITARY AUTOMATION

Volume 1 | January-February 1957 | Number 1

OUR MISSION

THE Department of Defense has pointed out that technological changes in the nature of warfare may soon demand widespread and fundamental changes in the structure of our Armed Forces as they now exist. President Eisenhower has indicated his general approval of developments that might permit the concentration of available manpower in those areas of greatest effectiveness for the safety and development of our nation. Some news columnists have avidly siezed on these pronouncements as auguring an exciting new round of interservice rivalry to determine which service should be the chief custodian of a "push-button weapon" which would obsolete all other forms of warfare, "small" or "large." This attitude sadly undervalues the true significance of events.

Rather, the emergence and perfection of integrated weapons systems comprising nuclear warheads, nuclear propulsion power, guided missiles, anti-missiles, and chemical and biological munitions require that organizational, logistic, tactical, and strategic planning of each branch of the service be continually coordinated with and oriented to these changing facts of military combat. The ability and genius of service leaders with proven combat experience, working cooperatively within the framework of the Department of Defense in the light of all the information that our scientists and engineers can provide is being brought to bear on this complex problem at all levels. Public debate on these issues can contribute little of value to our country's defense—but a great deal to the information and comfort of potential enemies.

However, there is a legitimate and useful area in which public journalism is vitally needed. Although the performance capabilities of our weapons, evaluations of military readiness, and even the existance of embryonic weapons must be shrouded in secrecy at the summit of the military information mountain, the greater body of information and technique which makes up the base of the mountain is unclassified. It is vital to our national security that these basic concepts be thoroughly and widely disseminated—not only among technical personnel of the American Armed Forces, but also among the civilian scientists, engineers and technicians who develop and maintain these complicated technical systems. Particularly among military line personnel, a functional understanding of automation* in all its military forms is needed to an ever-increasing degree. The new weapons systems have introduced complexities that would be insurmountable without help from the techniques of automation. Also, "cross-service" information on technical levels is needed to make unification operate. Rapid dissemination of this information to all levels cannot be accomplished by classified publications. Fortunately, the base of the mountain—the functional understanding of military automation needed by the American Militia—is as unclassified as Davy Crockett's powderhorn and rifle were in the days of the wild frontier. Part of the mission of *MILITARY AUTOMATION* thus becomes this wide dissemination of knowledge about the principles and practices of automation equipments to technical personnel working on military-type assignments, directly or indirectly.

Other countries recognize the importance of a large supply of technically and scientifically trained personnel in their population and are reported to be ahead of the United States in the *rate* at which scientists and engineers are being trained. State control of industry, research and education enables these countries to concentrate training in any desired direction. One American answer to this challenge can be to utilize the powerful educational force of commercial advertising to help overcome this lead. This is also a part of our mission.

Although automation is most often considered an industrial technique, the automation concept is not only a key military consideration, but historically grew out of the military into the industrial scene, rather than vice versa. Eli Whitney's invention of the assembly line method was first applied to the manufacture of muskets; fire-control computers preceded the use and development of general-purpose computers for industry; automatic techniques in military communications systems preceded such developments in industry; and automatic production systems for military electronic components were followed by their industrial counterparts. Significantly, automation has been developed most often and used first in the military, then in industry. It is fitting that these automation techniques for the military be given the recognition and treatment they deserve via their own publication, *MILITARY AUTOMATION*. This should, in turn, accelerate the rate at which the techniques develop and are applied in their inevitable industrial applications. This also is a part of our mission.

If our present military expenditures were to result only in large supplies of military hardware of rapid obsolescence rate, our society might well ponder their value. But the industrial implications alone of the research and development programs now under the aegis of the military could justify those expenditures—apart from the question of national security. Indeed, long-range security may well depend more on the progressive nature of our research, more on the channels of communication between industry and the military, more on the state of alertness and the intelligence of our military personnel, than on any stock-pile of munitions. Part of our mission thus becomes that of maintaining a clear channel between industry and the military, and of helping military personnel to keep themselves well informed and alert to the implications and applications of automation.

By furnishing a publication of wide distribution to technical military personnel in the armed forces, and to design engineers in supporting industry, featuring articles pitched at a practical "technical chief-to-officer-to-project engineer" level, we hope to increase and widen the fields in which each reader has a competent understanding; and, simultaneously, to help him relate the growth of his own specialty and branch to trends and developments in other branches of his own and allied services. We believe that in the unclassified and broadly defined field of *MILITARY AUTOMATION* we can provide that service, and this publication is our pledge that we intend so to do.—*Claude O. Morrison*

***Automation—the use of devices (electrical, electronic, mechanical, pneumatic and hydraulic) for performing automatic decisions and efforts—*Editors*.**

French Navy Switchboard

PARIS, FRANCE—The Laboratoires Central de Telecommunications, an IT&T Research Associate, has constructed a fully automatic telephone switchboard for the French Navy. This switchboard will replace the manual switchboards previously required to provide the dependability needed for combat and fire-control telephone circuits. The ability to withstand gunfire shocks, vibration, and rugged climatic conditions was achieved by eliminating all mechanical movements and metallic contacts, vacuum tubes, vapor tubes, and transistors in its design. Instead, it establishes interconnections by two basic components; (1) a silicon junction diode manufactured by LCT, and (2) a magnetic

Auto-Switches for French Ships

tripper comprising a saturable inductance placed in series with a capacitance to form a ferroresonant circuit. The speech currents pass through gates formed by these diodes and controlled by these trippers. The model shown here serves 20 subscriber lines, allows four simultaneous calls and two simultaneous dialings. Although now using magnetic amplifiers to supply ringing and busy tones, and employing standard dial subscriber sets, future design will reduce the weight of the ringing-tone generator and ruggedize the sub-set.

Supersonic Navigation

L.I.C., N. Y.—Ford Instrument Company has been awarded an Air Force contract in excess of

Computer Control

$15,000,000 for production of the ASN-7 all-weather navigation system that continuously and automatically tells a pilot where he is, the direction he should fly and the distance to his destination. Flight tested and evaluated at Florida's Eglin Air Force Base in 1955 and 1956, the ASN-7 will be installed in the latest high-speed fighter, reconnaissance, bomber and cargo aircraft.

High-Temperature Piezo-element

NEW YORK, N. Y.—Pilot production of limited quantities of lead metaniobate, an unusual new high-temperature material with numerous possible defense applications in guided missiles and jet engines underway at the General Electric Company. Lead Metaniobate is a piezoelectric material, which gives off small voltages when acted upon by outside physical forces such as vibration. It retains most of its properties up to 500 degrees, Centigrade.

Missile Ship Stabilized

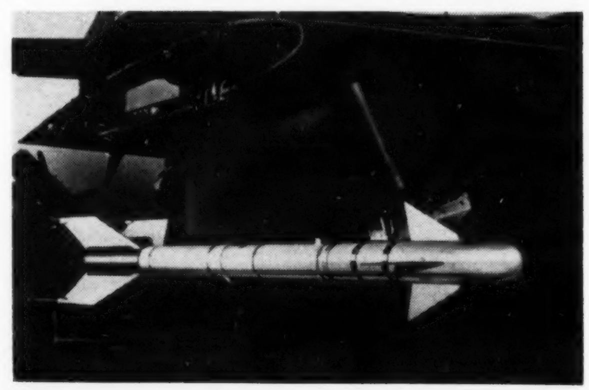
NEW YORK, N. Y.—U. S. Navy's experimental ship, COMPASS ISLAND, forerunner of a fleet of nuclear-powered surface and submarine ballistic

Missile Ship Grows Fins

missile launching vessels was commissioned December 3rd, 1956, at the New York Naval Shipyard. Key to its all weather, all latitude, day and night capability is the ship's inertial navigational system (SINS), a new development of the Navy's Special Projects Office of the Bureau of Ordnance and Sperry Gyroscope Company. The system determines ship position (latitude and longitude), true North, and the ship's speed over "ground." With known target location and ballistic trajectory, success depends on knowing location of the launching point to a degree of accuracy never hitherto attained at sea. This is done with a telescope that automatically aligns itself upon a star by means of photoelectric cells. The telescope is mounted on a stabilized platform which will remain precisely level regardless of rolling and pitching of the ship. Underwater fin stabilizers reduce ship's roll to $1\frac{1}{2}$ degrees in a sea that makes sister ships roll 15 degrees. Action of the Sperry Gyrofin stabilizer is automatically controlled by instruments which measure roll rate, roll angle and roll acceleration then compute proper stabilizing moment. Compact sensors then transmit, through magnetic amplifiers, the required anti-roll signals to hydraulic actuators which directly operate each fin shaft. Fins may be retracted into recesses in the hull when not in use.

Sidewinder

PHILADELPHIA, PA.—"Sidewinder" air-to-air guided missile is now being produced for the Navy Department, Bureau of Ordnance, by Philco's Government and Industrial Division. Small and light enough to be carried in quantity by single-seat interceptor planes, the missile may be fired singly or in salvos. Sidewinder requires no complex launching equipment, is maneuverable at supersonic



speeds, has an unusually high single-shot "kill" reliability, requires no special pilot training and may be launched well beyond reach of an enemy aircraft's defense. The Navy, with aircraft carrier space limitations, is especially enthusiastic about the weapon's simplicity, small size and light weight. Sidewinder, using thermic homing, was developed by the Naval Ordnance Test Station, China Lake, Calif. (*See article this issue.*)

Thinnest Wing Flying

BURBANK, CALIF.—Unusual configuration of the new Lockheed F-104 Starfighter, designed for sharp maneuverability at supersonic speeds, is demonstrated in this first flight photo. Wings, thinner than on rocket planes, are almost knife-keen on the edge and slant downward from the fuselage.

For precision control at supersonic speeds, the horizontal stabilizer is placed high on the fin and moves as a single unit. Production models use the new General Electric J-79 engine, possessing the highest ratio of thrust per pound weight of any engine in its power class.

Separate units of the integrated electronics system can be quickly plugged in place, or unplugged, to provide the airplane with only the electronics equipment needed for a specific mission being flown. Unnecessary weight is thus eliminated.

Printer Plotter

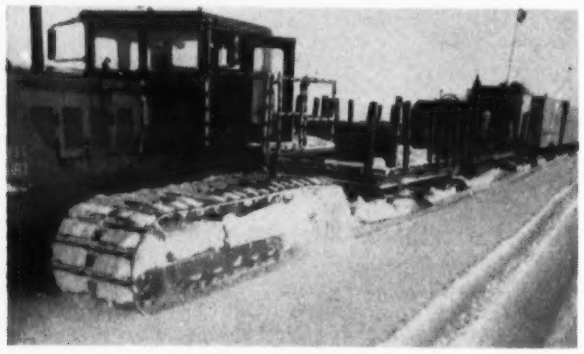
ABERDEEN PROVING GROUND, MD.—An ultra-high-speed printer-plotter (BEPOC), has been developed by Burroughs Corporation for the Ballistics Research Laboratories under an Army Ordnance Contract. It can accept the high-speed output of a computer. Used in connection with ORDVAC, the Proving Ground's Ballistic Research Laboratory computer, BEPOC actually operates as a high-speed page printer in translating the computer's words into printed plotting positions and alphanumeric information on continuous rolls of page-width paper at a speed of 300 plotting points per second. In tests a laboratory model has printed 5,000 characters per second serially.

BEPOC has been confined to test work on existing ballistic missile data, but could be applied to actual "in flight" data to produce a second-by-second record of missle's flight, giving position, operating characteristics and environmental conditions.

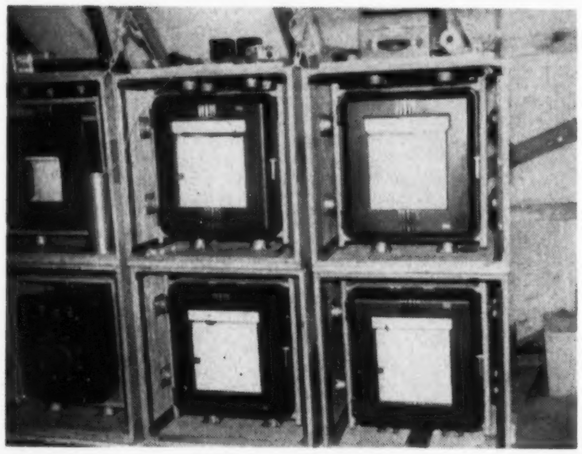
Consideration is being given to using BEPOC in conjunction with ORDVAC to process data from the 80 rockets to be fired at Ft. Churchill during the U. S. participation in International Geophysical Year experiments. Plans are also being considered for its processing data from the nation's first Earth Satellite.

Recorders Withstand Arctic

PHILADELPHIA, PA.—Scientists from the Snow, Ice and Permafrost Research Establishment, Corps of Engineers, U.S. Army, took Leeds & Northrup instruments to the 2-mile-thick Greenland ice cap for snow drift and whiteout studies conducted by the Climatic and Environmental Research Branch of SIPRE. Speedomax recorders accurately measured air temperature, dew point, radiation and other variables for seven weeks of continuous operation.



Tractor pulls "wannigans"



7-Weeks of Cold Facts

Ceramic Coated Wire

NEW YORK, N. Y.—A wire capable of withstanding extreme temperatures with a surface that will take a ceramic coating is being produced in diameters ranging from 5 to 70 mils for use in motors, transformers and other electrical components in the high-temperature, radiation-tolerant equipment line.

The new wire, developed by G. E. Lamp Leads and Bases Dept., is to be manufactured in quantities sufficient to supply other operating departments for use in their own development of equipment.

...in IBM Military Products?

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Systems Engineers oversee the engineering support provided by the Systems Coordination and Specification Group to the factory on the AN/ASB-4 Bombing-Navigational System. Air Force requirements are analyzed and the resulting engineering changes evaluated to determine effect on system performance and accuracy. Mathematical error analyses are run. *Do you belong on this team?*

Systems Analysts anticipate performance and recommend design criteria before and during development of equipment. Later, they compare dynamic performance accuracy and reliability characteristics with what has been anticipated. Other assignments include Digital Computer Systems Engineering, Input-Output and Analog-Digital Conversion Engineering. *Do you belong on this team?*

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Quentin Marble (left): B.S.M.E. 1951, Syracuse. Joined IBM in 1951; promoted to Design Engineer in 1952; May, 1955, promoted to Associate Engineer, and then to Project Engineer, Manager of the Systems Coordination and Specification Group, Production Engineering Department, in February, 1956; shown here describing a unique cooling design to a new employee in his group.

Monroe Dickinson (left): B.S.E.E. 1952, W.P.I.; M.S.E.E. 1954, M.I.T. Technical Engineer in analog and alternate computer techniques for weapons systems, 1952; Associate Engineer responsible for systems design and analysis, 1954; December, 1955, Staff Engineer, responsible for research planning; here reviewing set-up on laboratory analog computer of a sampled data control problem.

loyee. IBM Military Products include the Airborne Computer Laboratories located in Owego, N. Y., and the Project SAGE installations directed from Kingston, New York.

Here is a real ground-floor opportunity that you can't afford to overlook. Without exaggeration, your potential in this dynamic young field of electronic computers is virtually unlimited. Get all the facts. Write, outlining your background and interests to:

. A. Whitehorne
Manager of Engineering Recruitment, Dept. 9102
International Business Machines Corp.
590 Madison Ave., New York 22, N. Y.

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MATHEMATICS
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INSTALLATION
CIRCUIT DEVELOPMENT
POWER SUPPLIES
TRANSISTORS
HEAT TRANSFER
OPTICS
TEST EQUIPMENT
COST ESTIMATING
TECHNICAL PUBLICATIONS

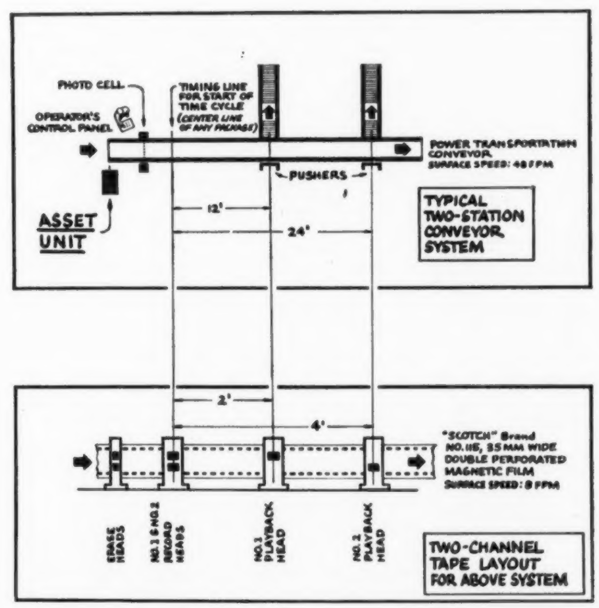
Automatic Conveyor System

LOS ANGELES, CALIF.—A magnetic tape-controlled conveyor system called ASSET—Automatic Selected Station Electronic Timer—developed by the A. J. Bayer Co., Los Angeles, is claimed to have saved the Air Force $100,000 per year *per supply depot.* (Seven units are in operation so far.)

Used on transportation-discharge conveyors, where packages are shunted off to a series of branch conveyors, it affords the single operator (at the loading end) the possibility to select the discharge

Air Force ASSET Sorts BOXES

point for the different parcels: He simply pushes a selector button on the control panel and presto . . . the package will turn off the main conveyor to slide down the appropriate branch. How it is done? By a photocell, 35-mm magnetic film (the "memory"), a recording head, a playback head, relays and air-powered pushers. The system even handles more than one conveyor: Recording heads arranged in banks of five record a multitude of channels on



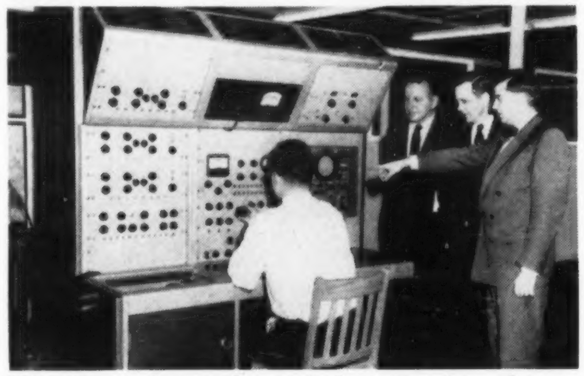
the tape. Signal lights, a "cancellation" switch, a "repeat" switch, etc. mounted on the control panel make it possible to cut in on the automatic control after pressing the selector button.

The longest conveyor system operated by ASSET to date is a 750-ft endless-belt type.

News—*continued*

Jitter Analysis

NEW YORK, N. Y.—A complex-motion compensation console built for vibration research and development in guided missiles and supersonic aircraft culminates three years of development at MB



Mfg. Co., and provides a vital engineering advance in simulating airborne vibration environments and predicting component reliability. Instrument panels on the Model T67 include an electronic amplifier, a high-frequency electrodynamic exciter and a control console.

News Bits

► Army, Navy and Air Force have been assigned separate responsibilities for electronics production-preparedness measures for components, subassemblies and production materials. The authorizing Defense Dept. directive (4240.1) does not limit or restrict the procurement of these items by any of the services for current or future needs.

Assignment of responsibility under the terms of the order gives the Army monitoring of preparedness measures for coils, quartz crystal oscillator plates, dry batteries, resistors, accurate film types, fixed and variable wire wound (including power, low-power, precision and cast) resistors, sockets, connectors, plugs, telephone keys, telegraph keys, loudspeakers, headphones and microphones, transistors and crystal diodes, tubes and hydrogen thyratrons.

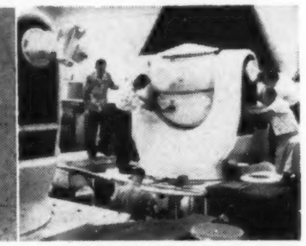
The Navy gets responsibility for capacitors, dry rectifiers, vibrators, fixed and variable composition (including high power) resistors, military and commercial synchros, transformers, all power, transmitting, microwave and miscellaneous tubes (other than those named below).

The Air Force gets responsibility for relays, switches, thermistors, klystrons, magnetrons, TV, ATR and related types, traveling-wave tubes and related types, and high-temperature wire.

The directive is designed to (1) establish and maintain an adequate production base to meet Defense needs, (2) promote greater efficiency, shorter leadtime, flexibility of capacity, economy of operation and conservation of materials, (3) minimize the vulnerability of essential production capacity, and (4) promote inventory measures to ensure timely availability of component parts, subassemblies and production materials.

► Flight control system for Lockheed's X-7 missile, a supersonic ramjet-powered test vehicle, has been supplied by Lear since inception of the project in 1949. After launching from a B-29 the X-7 accelerates to ramjet speed by rocket, performs its prescribed test mission and then is decelerated and recovered by parachutes. Missile's flight control system has to withstand severe shocks of repeated recoveries without damage.

X-7 Missile



Bell shock tester

► Bell Telephone Laboratories, participating in the Air Force ballistic missiles program, is subjecting electronics components to severe shock, vibration and extreme-temperature tests and working on guidance systems for long and intermediate range weapons. The Air Force program consists of two intercontinental missiles, Atlas and Titan, as well as an intermediate range missile called Thor.

► Complete sets of Air Force-Navy Aeronautical Standards, Air Force-Navy Aeronautical Design Standards, U. S. Air Force Standards, and Military Standards, as listed in current indexes of the Air Force and Bureau of Aeronautics of the Navy, are available, bound, in six three-ring binders. In addition, other Military Standards not currently listed but used by the Air Force or the Bureau of Aeronautics have been included. The cost is $220; includes a one-year mailing service for all new and revised AN, 6-digit AN, AND, USAF, and MS Standards as issued. Supplier requests payment with order.—National Standards Association, 616 Washington Loan & Trust Building, Washington 4, D. C.

► Motorola recently demonstrated microwave equipment for relaying radar information whereby search radar and other radar data can be relayed to a control point for analysis or traffic control. PPI radar indicators received input from a two-hop microwave system some 24 miles in length. One system will be installed by CAA to collect air traffic information at Indianapolis from a radar network in the northern half of the Indianapolis Air Route Traffic Control Center area, a zone about 400 miles long and 140 miles wide. It will tie in with an existing microwave network originating at the U. S. Air Force Base in Jamestown, Ohio, and be used to evaluate improvements in air traffic control.

TRENDS

Military electronic expenditures for 1957 are expected to reach $3.8 billion: Air Force—$2 billion, Navy—$1.3 billion and Army—0.5 billion.

Marine Landing Vessels equipped for remote radio control by Lear, Inc. are used to test landing conditions in heavy surf. It has been found that all of the usual driver controls can be remotely manipulated from a hovering helicopter better and faster than is possible by the conventional coxswain-engineer control—and without endangering sailors lives.

The most powerful shipborne radar set ever put in service has been installed on the USS Northampton Task Force Command Crusier. This new eye of the fleet, with 400-mile vision, is powered by a 10-million watt peak-power magnetron. The permanent magnet for this oscillator weighs 300 pounds.

Transistor production in 1957 is expected to reach 20-million units from 11-million in 1956. Conversely, price reductions of from 10% to 50% are being made by one manufacturer (Texas Instruments) in various types in January 1957. The old story of increased quantity and quality going hand-in-hand with lower unit costs.

Closed-circuit television circuits available for military use provide improved vigilance in maximum security areas, in close observation of dangerous operations, in observation of remotely-controlled operations, and in permitting many observers to view operations accessible only to a few.

Naval Research Laboratory scientists in operation DEEPFREEZE recently designed a 1200-ft-high radio antenna, using a Jalbert JX-9 Zeppelin-type balloon as a "skyhook." While installed aboard the USS GLACIER, it maintained reliable communication with "fly-in" planes all the way from their New Zealand base to the Antarctic. This was the only method of homing available to these planes.

The U. S. Naval Training Division Center has used a television camera to photograph colored motion pictures of the human eye. This project was carried out in cooperation with the National Institute of Health to demonstrate the adaptability of closed-circuit television to educational uses.

The ambient temperature operating ceiling for transistors is being raised by the employment of silicon instead of germanium, according to G. E. engineers.

Titanium has been found by G. E. scientists to possess superior "gettering" properties in the absorption of residual gas during manufacture of vacuum tubes.

Letters to the Editor

Dear Commander Morrison:

I have just received a letter from your company advising me that you have taken over the assignment of Editor of MILITARY AUTOMATION.

As a new man in industrial electronics, I am very much interested in this field. I have just been given the assignment of Manager of Market Research for our company and am a comparative newcomer to automation and industrial electronics. Any information of a general nature that would assist me in orientating myself to this field would be most appreciated.

Sincerely, E. A. M.

Orientation in any field which is developing as rapidly in its many aspects as military and industrial electronics and automation is a formidable problem, either to a newcomer or to an old-timer who has, in the past, been occupied chiefly in some limited area of the field. To a certain degree, your problem is one that may be faced by many military officers whenever they receive a new assignment which deals with electronic equipment maintenance, design, procurement, or one of the many new applications of automation to data processing or information retrieval. One difficulty is that most information that has been published has pertained to individual trees, whereas you are primarily interested in the extent and composition of the forest.

This thought has guided our planning for MILITARY AUTOMATION. Accordingly, we believe you will find some immediate help in this issue, with much more to come. In addition to the basic technique articles begun in this issue, we are planning a series of surveys, which will cover the entire field of military electronics, controls, and automation. Organizational differences between the different Armed Services make this picture confusing, although from the viewpoint of the manufacturer, the new Federal Stock Catalog—with its requirement "that only one name, stock number, and specification shall be used to describe any one component bought and stocked by the government"—is a giant step toward simplification. Prior to this, a single small blower-motor might have been given a different number by the Army, Navy, and Air Force, and the Government Services Agency would probably have tagged it with a fourth! The Federal Stock System will be explained in a forthcoming MILITARY AUTOMATION article.

Besides direct contact with government purchasing agencies, you will be interested in identifying the many prime contractors who might sub-contract for your services and products, and in suppliers of components which your company might utilize. In this respect, we believe that you will find that the subcontractor who supplies components for military equipment will meet with less competition than if he were bidding on components for commercial equipment. This is because MIL specifications require a certain custom-tailoring to meet those specifications which cannot be satisfied by mass-produced commercial components. Because we recognize that changes in MIL Specifications are of interest to many of our readers, we plan to run selected notices from the ASESA*, beginning with our second issue.

We appreciate your inquiry, and hope our articles will bring you the information you are seeking. Our sister publication, INSTRUMENTS AND AUTOMATION, and particularly the 1957 Handbook and Buyer's Guide should be of assistance in industrial marketing problems outside the military field.

*Armed Services Electro-Standards Agency, Fort Monmouth, New Jersey

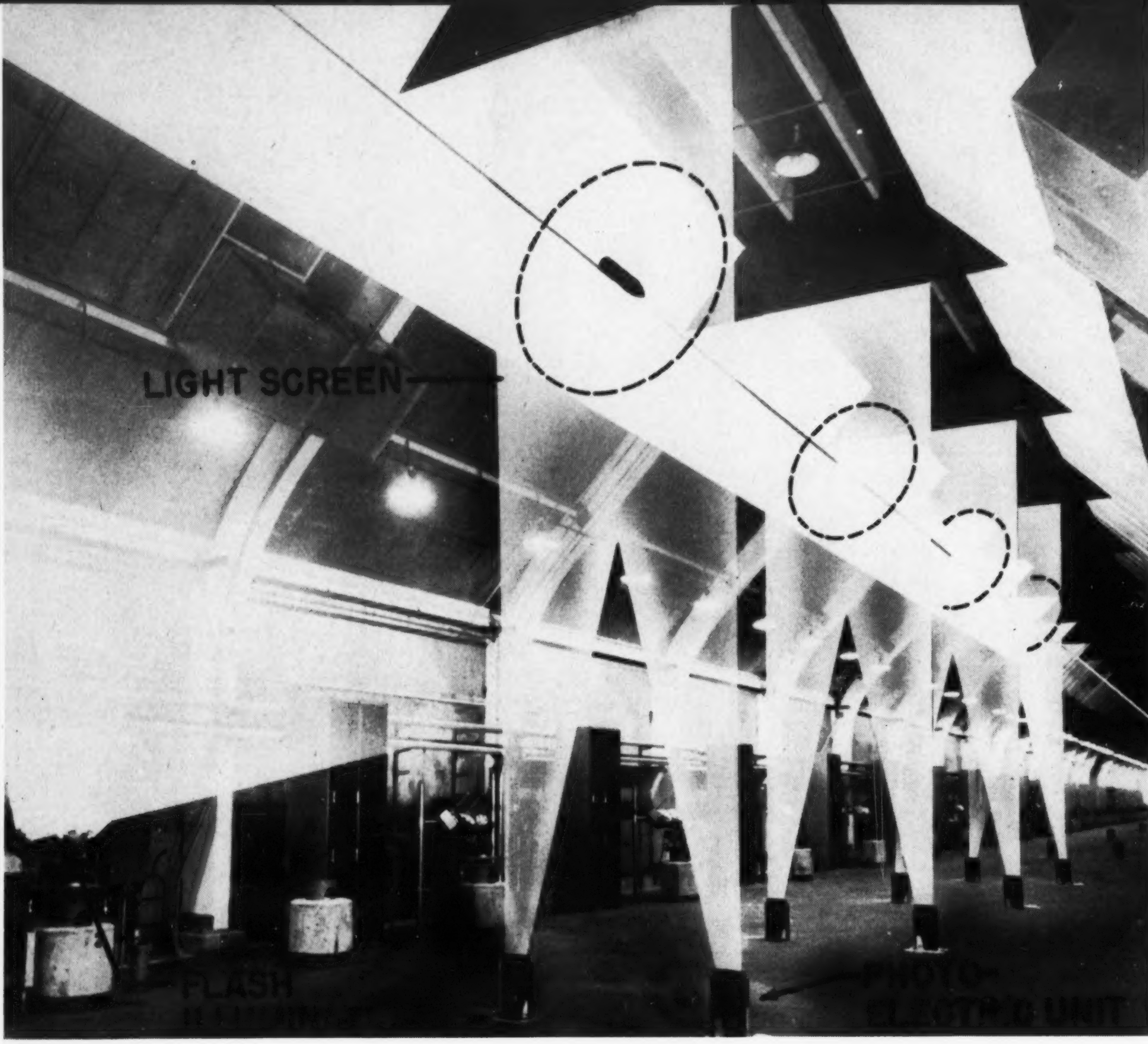


Fig. 1. Missile passing through light screens, which are located at 4' intervals along the 500' range building. (Official United States Navy photograph.)

Dynamic Aeroballistics

SAMUEL E. DORSEY

U. S. Naval Ordnance Test Station, China Lake, California

Basic techniques for aerodynamic and ballistic studies are (1) wind tunnel, (2) aeroballistics laboratory, and (3) open range. The wind tunnel has minimum cost and provides rapid analyses of static parameters, but is not as adaptable to study of dynamic parameters as is the aeroballistics laboratory, which is intermediate in cost between the wind tunnel and the open range. The NOTS Thompson Aeroballistics Laboratory features ballistic photography, remote centralized control, and complete monitoring of 30 stations. Even the monitor system is monitored!

U. S. NAVY is the world's largest research and development sponsor, and the U. S. Naval Ordnance Test Station (NOTS) is the Navy's largest ordnance research and development center. NOTS has 1400 military personnel and nearly 5000 civilian personnel in its laboratories, test ranges and experimental production plants for rockets, guided and unguided missiles, torpedoes, fuzes, and other ballistic ordnance equipment. All rockets presently in use by the U. S. Navy and the U. S. Air Force were developed at NOTS.

The largest NOTS facility is that at China Lake, Calif., covering more than 1000 square miles of the Mojave Desert. About 50 miles away from the main station area centered at China Lake is the 750-square-mile Mojave "B" Range used for aircraft-rocket and gunnery firings; this area also includes the Randsburg Wash Projectile Range used for testing weapon fuzes. Other NOTS facilities include (1) a Pasadena Annex of NOTS

The Author

Samuel E. Dorsey has been with the U. S. Naval Ordnance Test Station since December 1945. He received his B. S. in Electrical Engineering at Georgia Tech in 1941 and M. S. at UCLA in 1952. He is a registered Professional Electrical Engineer in the State of California. His specialty is designing electronic circuits, mostly control instrumentation.

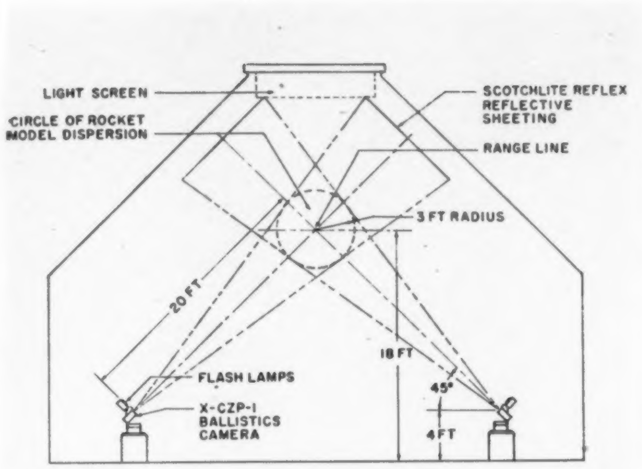


Fig. 2. Geometry of triggering system and silhouette photography, as related to a pair of cameras.

(about 150 miles from China Lake) which has a large plant, (2) the Morris Dam Test Range near Azusa, which is used for torpedo and underwater trajectory studies, (3) sea range test facilities at Long Beach and San Clemente Island.

At NOTS, chemists are at work on solid and liquid propellants, hydropropellants, high explosives, combustion phenomena, etc.; physicists are at work on projectiles, photoconducters, gas dynamics and optics; mathematicians are at work on heat-flow problems, statistical analyses, and servomechanisms; ballisticians are at work on aerodynamic design, rocket and guided missile ballistics.

A NOTS maxim is "One test is worth a thousand opinions," and NOTS has the most completely instrumented test ranges in the country. (Future articles in *MILITARY AUTOMATION* will discuss the instrumentation of open ranges and wind tunnels, which are two of the three basic techniques used for aerodynamic and ballistic studies—the third is the aeroballistics laboratory, the subject of this article.—Ed.)

The control and monitoring instrumentation of the NOTS Aeroballistics Laboratory includes electronic instrumentation operating directly to generate the signals which trigger precisely-timed light flashes used for ballistic photography of missile models passing through the Laboratory.

The Laboratory itself is a high-precision, enclosed range for the experimental determination of the aerodynamic and ballistic characteristics of rocket and missile models (Figs. 1 and 2). Inert models are launched from guns ranging in size from 40-mm to 8-inch, and pass in free flight through the 500-foot-long range building. The models can be photographed at 4-foot intervals during their flights with photographic coverage provided by 23 pairs of precision ballistics cameras arranged so that fields of view of adjacent cameras are overlapping.

This arrangement provides continuous coverage of the rocket model during its flight through the Laboratory, every camera photographing the model six times to give a total of 138 pairs of images.

Adjacent to each camera is an electrical-discharge flash lamp (Fig. 3), the source of microsecond-duration illumination of the rocket models in transonic and supersonic flight. Flash lamps provide a series of accurately-timed light flashes during the interval that the rocket model is in the field of view of the two related cameras. Flash illumination is intensified by use of a background of Scotchlite reflex sheeting.

The action at each of the Camera Stations spaced throughout the five-hundred-foot-long enclosed Range Building, is briefly as follows: A Master Timing System (supplying all Stations simultaneously with a continuous train of accurately-timed pulses) feeds the input to a normally-blocked gate circuit in a *Gating Unit* (Fig. 4). A line light source, called the *Light Screen*, is situated on the ceiling of the building over the point of entry to the fields of view of the two cameras, its light directed to two *Photoelectric Units* in the floor. When the missile model intercepts a small part of the light received by either Photoelectric Unit, a signal is generated which activates the Gating Unit, allowing the precisely-timed pulses to pass in a "burst" whose length is controlled by a preset electronic timer. This burst of pulses is amplified by a Driver Unit to form the inputs to two *Flash Units* whose bias is also supplied by the Driver Unit. The source of energy common to all Flash Units in the laboratory, from which each draws power to operate its flash lamp, is a 500-microfarad capacitor bank charged to 10,000 volts. The voltage furnished each lamp, after the first flash in each burst, rises to almost 20,000 volts due to resonant charging. One lamp is associated with each camera.

The control and monitoring of the electronic circuits are performed in the control room of the laboratory (Fig. 5). Almost every electronic and electrical function of the Laboratory is subject to remote control; manual operation is necessary only to load the cameras and the launching gun (Fig. 6). Once these manual operations have been completed, the entire sequence is automatic, from the opening of the camera shutters and the firing of the gun to the closing of the camera shutters after the missile model has passed through the Laboratory.

All remotely controlled action is initiated by the push of a button on the *Control Console*, whose operator not only exercises push-button operation of the Laboratory but visually monitors both the status and performance of the major electronic and electrical circuits in the Laboratory proper and in the Control Room.

Power Contol

Control of the primary power for the Laboratory is exercised from the left turret of the Control Console. From here, on-off and increase-decrease control of the 150-volt, 100-ampere d-c power source for the Light Screens is exercised, as is on-off control of the 115-volt, 60-cycle, 3-phase power for the Console, Control Room Racks, Range Power, illumination of the Laboratory

Fig. 3. An electrical discharge flash lamp is adjacent to each camera. (Official United States Navy Photograph.)

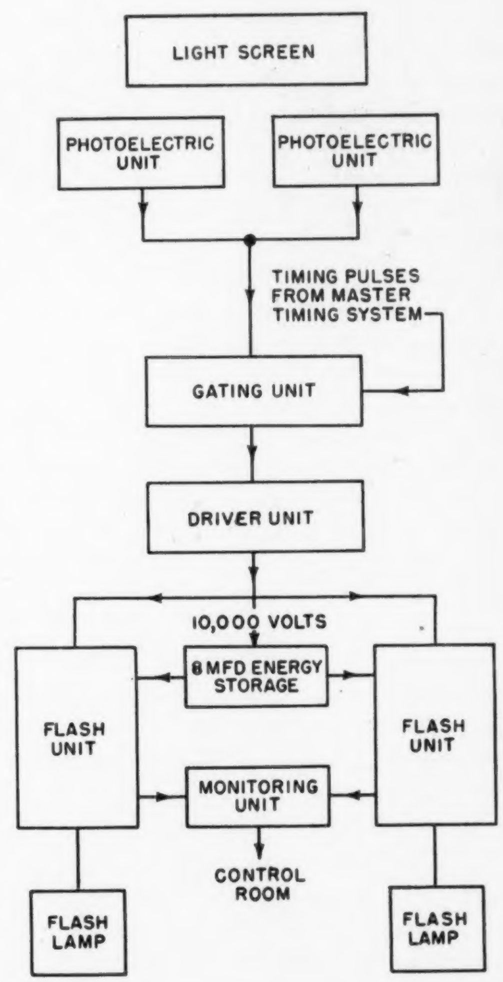


Fig. 4. Block diagram of flash-station electronic instrumentation.

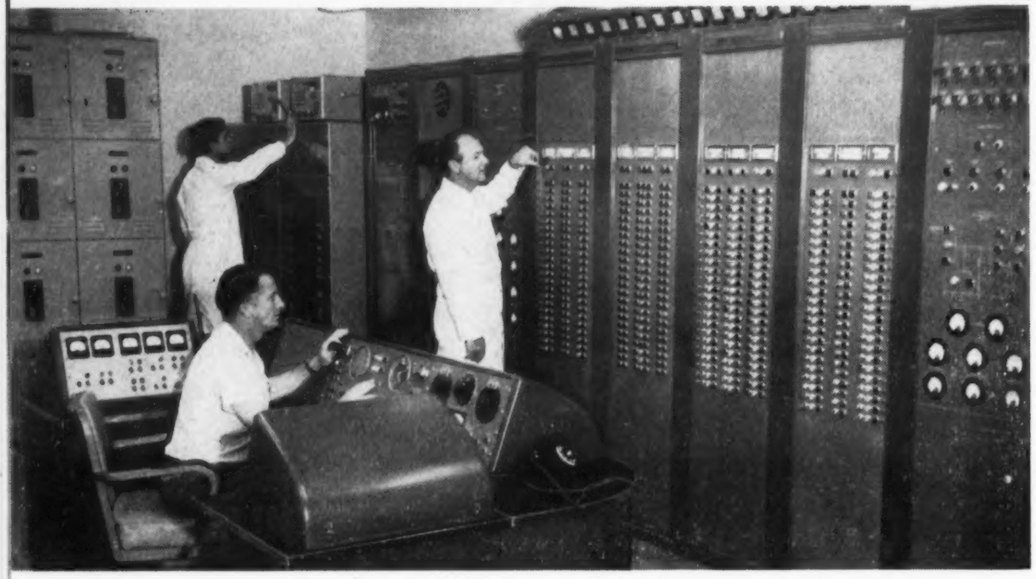


Fig. 5. Control console. (Official United States Navy Photograph.)

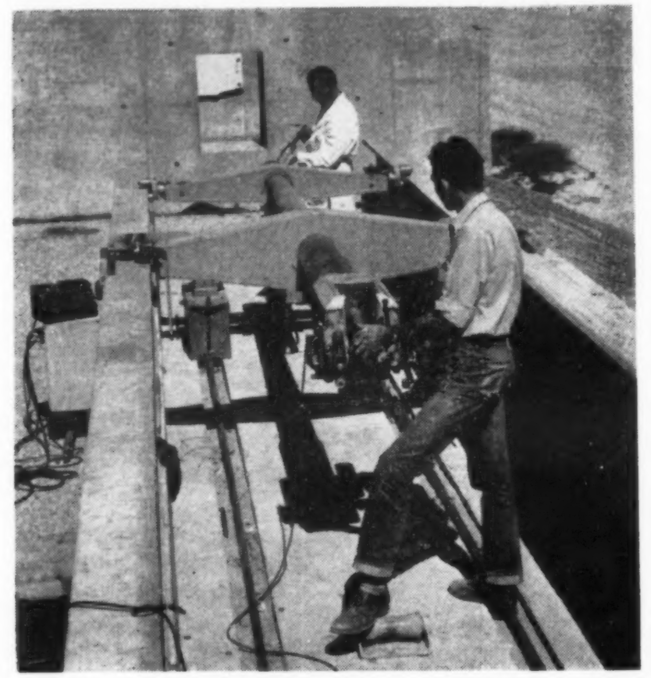


Fig. 6. Loading the gun (and cameras) is the only manual operation required.

proper, and Air Conditioning. All power switching on the Console is done via push buttons accompanied by on-off-indicating pilot lamps. Meter readings of the d-c voltage and current and of the voltage on each of the three phases of the a-c power are continuously available.

The right turret contains the control and part of the monitoring of the 10,000-volt d-c power supply which charges the 500-microfarad capacitor bank.

The monitoring scheme of the high-voltage system is completed by a panel in one of the racks in the Control Room (Fig. 7). This panel is in plain view of the operator and shows graphically, by means of a simple circuit diagram with pilot lamps for switch positions, the status of the large, manually operated switches on the control board of the capacitor bank.

Added to the high-voltage power supply is a motor with gearing assembly for the electrical control of a Transtat (variable auto-transformer) which adjusts the output high voltage. This control may be local or remote from the console. Limit switches on the drive shaft of this mechanism provide an upper limit of 10,000 volts and also require that the Transtat be returned to the off position before the power supply can be turned on.

Master Monitoring System

Twelve vertical sets of monitoring pilot lights are shown on the center racks of Fig. 5. These are a part of a *Master Monitoring System*. The status of the following electronic and electrical circuits for *each* of the operating Stations is monitored with pilot lamp indications:

(1) Camera Stations **ON** or **OFF.**

(2) Flash Unit Rack Doors **OPEN** or **CLOSED.** If any one of these doors is open, the operator at the Control Console does not turn the high voltage on.

(3) Light Screen Lamps **ON** or **OFF.** An OFF signal is given if any one of the eleven lamps in a Light Screen is burnt out.

(4) Flash Unit Rack High-Voltage Disconnect Unit **OPERATIVE** or **NON-OPERATIVE.**

(5) Flash Voltage **ON** or **OFF** each of the two flash capacitors at each Station.

(6) Flash Unit Thyratron Bias **TOO LOW, SATISFACTORY,** or **TOO HIGH.**

(7) Both Camera Shutters **CLOSED** or one or both **NOT CLOSED.**

(8) Camera Fiducial Lamps **READY** for exposure, **EXPOSED,** or **FAULT.**

The last four sets of lights monitor the status and performance during missile model test (or electronically simulated firing) of the following electronic and electrical circuits:

(9) Station Gate **READY, SATISFACTORY** operation, or **FAILED.**

(10) Driver Pulses **READY** for monitoring, **RECEIVED** at the grids of the thyratrons during cycle, and **NOT RECEIVED.**

(11) Resonant Charge **READY** for monitoring, **SATISFACTORY** during cycle, or **FAILED.**

(12) Camera Shutter Cycle **READY, SATISFACTORY** operation, or **FAILED** (failed to open or failed to close).

Note that there are 30 functions (30 vertical rows of lights) for 23 stations plus 1 master monitor station—giving a total monitoring array of 720 pilot lamps. But it is not necessary for the operating engineer to keep his eye on the full array. The top row (master monitors) is provided so that if any one of the 12 master monitors gives an indication of difficulty, the operating engineer need only scan a particular column of pilot lamps. The monitoring has been carried even one step further: a monitor of the master function monitor appears on the Control Console, and under conditions of satisfactory status and performance the engineer need not even glance at the monitoring racks.

There are several reasons for this elaborate monitoring system. First, the cost of a single test on a rocket model in the Laboratory is sufficient to warrant providing some means for obtaining a reasonable assurance that the complex electronic and electrical instrument system is functioning properly. Second, when trouble does occur, it can be readily localized anywhere within the 500-foot-long building, thus aiding in reducing delay due to failures. Third, the Monitoring System provides a measure of safety to both personnel and instruments. This Monitoring System warrants detailed consideration.

Simple Switch Monitoring

Part of the monitoring of each Station involves the indication of whether certain switches are open or closed. In the Station ON or OFF (the first two rows of lights) the switch is formed by one pair of contacts of the relay which controls the operation of that Station. The same is true of the high voltage disconnect and camera fiducial lamps. The monitoring of the Flash Units rack doors and the camera shutters consists simply of limit switches.

Camera Shutter Control and Monitoring

Details of the camera shutters control and monitoring for a single station are shown in Fig. 8. Normally, the shutters of both cameras should be closed, closing switches S1L and S1R as shown. These switches are connected in series to the shutter pre-cycle relay in the Control Room. As the circuit is made through this relay to power voltage, the relay is energized and its armature actuated as shown. The condition of SHUTTER CLOSED is indicated by the lighting of the green lamp. If either switch, S1L or S1R, were not closed, the red lamp would indicate SHUTTER NOT CLOSED.

When both shutters are open, the switches S2L and S2R are closed and complete the power circuit to the shutter cycle relay, causing it to actuate. An "end-of-run" relay furnishes power before the run to the green SHUTTER READY lamp if the shutter cycle relay is not energized. After the run, it furnishes power to the

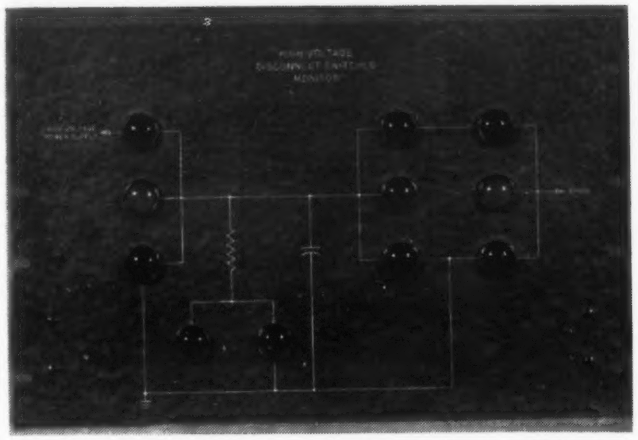


Fig. 7. High Voltage Monitor Panel shows switch positions in the high-voltage capacitor-charging system. Note graphic display. (Official United States Navy Photograph.)

white SHUTTER CYCLE O. K. lamp if the shutter cycle relay is energized. Should the shutter cycle relay be energized before the run, or not energized afterwards, the red lamp indicates CYCLE FAULTY.

The shutter opening and shutter closing switches (part of the Sequence Cam Unit to be described later) operate all cameras in parallel. In each camera there are two cams on the shutter motor shaft. The cam to the left (left camera, Fig. 8) holds the shutter closed for the normal condition. In this position the smaller cam holds switch S3L compressed, connecting the shutter motor to the shutter-opening switch on the Sequence Cam Unit for power, and disconnecting it from the shutter-closing switch. Momentary closure of the shutter-opening switch applies power to the shutter motor, driving the shaft until the small cam pulls away from switch S3L. This action disconnects the shutter motor from the shutter-opening switch and connects it to the shutter-closing switch. The motor stops with the shutter open. The shutters of all cameras remain open during the flight of the missile model. At the end of the run, the shutter-closing switch actuates, again applying power to the shutter motor until it has time to rotate the small cam to the position shown in Fig. 8, wherein operation of switch S3L opens the circuit and the shutter is closed once more.

Light Screen Monitoring

The Light Screen in each Station contains six 60-watt lamps and five 25-watt lamps. Should one or more of the eleven lamps fail to light, the decrease in current (about one-fifth of an ampere) supplied to the sampling resistor would introduce a differential of half a volt into the signal input grid of the monitoring amplifier, which actuates the Light Screen monitoring relay.

A short swing of a potentiometer carries the pilot lamps through the red-green-red cycle for balancing the circuit.

Gate Monitoring

The gate monitoring circuit for a single Station is shown in Fig. 9. This circuit provides pilot lamp in-

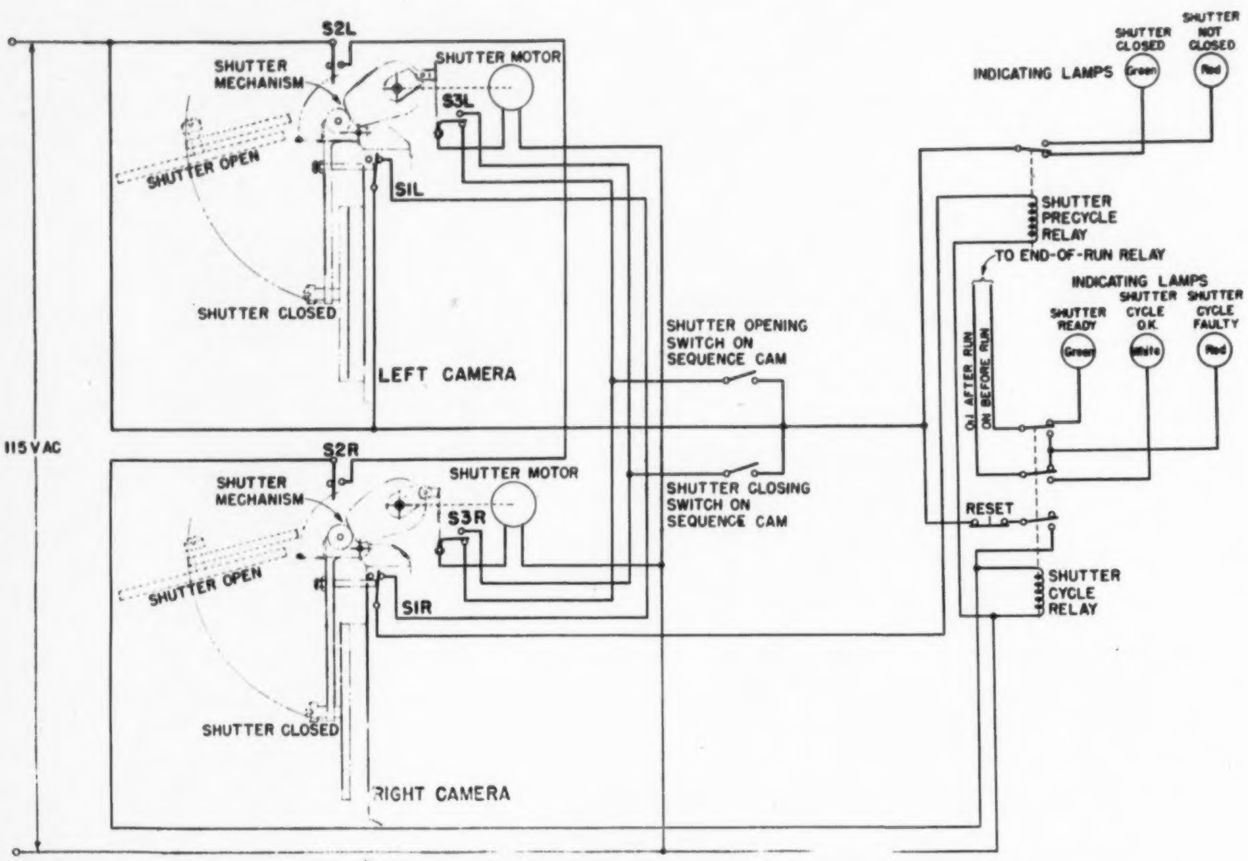


Fig. 8. Camera-shutters control and monitor circuit.

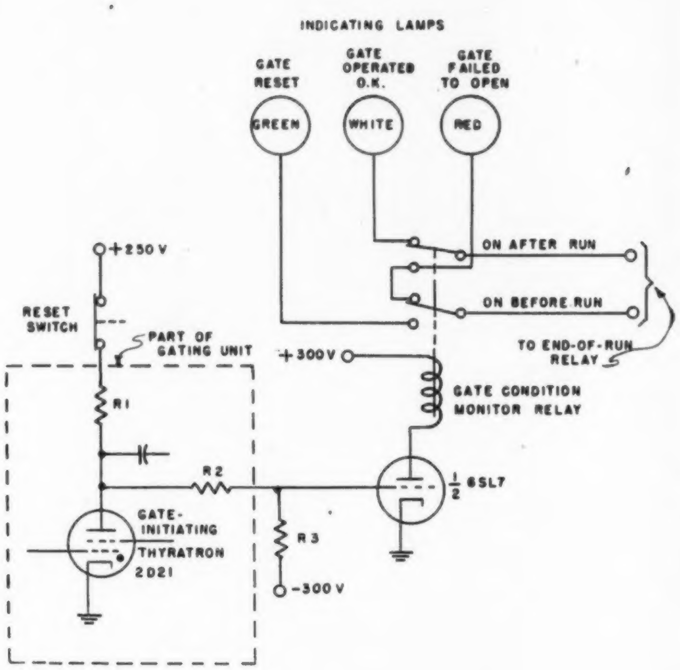


Fig. 9. Gate-monitor circuit.

dication of the condition of the gate or "start" thyratron in the Gating Unit. When the thyratron is fired, it remains conducting, the voltage at its plate drops, and the plate current of the triode is cut off. The gate condition relay then lights the red pilot lamp. At the end of the sequence, the "end-of-run" relay actuates, lighting the white pilot lamp.

When the RESET switch is actuated, the supply of positive voltage is removed from the plate circuit of the start thyratron. On release of this switch, the thyratron should remain non-conducting, in which case the voltage at its plate climbs to nearly that of the supply. Now the voltage at the grid of the monitoring triode goes positive (limited by the flow of grid current in the triode), causing it to actuate the Gate Condition Relay. Normally, the End-of-Run Relay is released at the same time that resetting takes place. Thus, the green lamp lights. If the start thyratron is non-conducting after a sequence is run, before reset, the end-of-run relay (through the energized gate condition relay) lights the red lamp, indicating FAULT.

Monitoring the Flash Units

The remaining four monitoring schemes involve checking of signals within the two Flash Units of the individual Stations. Included are the monitoring of high voltage, resonant charge, thyratron bias, and driver pulses, the circuits for which are shown in Fig. 10. To the upper left appears a Flash Unit, two of which are at each Station of the Laboratory. To the lower left is shown one channel of the two-channel L-R Monitoring Unit. The other Flash Unit, as well as the remaining channel of the L-R Monitoring Unit, connect as shown to the two monitoring lines running back to the Control Room.

Flash Voltage and Resonant-Charge Monitoring

The flash voltage and resonant-charge monitoring system (Fig. 10) indicates the presence of d-c high voltage on the flash capacitors in both Flash Units and the occurrence of resonant charge. If high voltage is absent from one of the flash capacitors, the voltage on the grid of V1 goes far enough negative that its plate current can no longer hold the High Voltage Monitor relay actuated. In this case, the red FLASH VOLTAGE LOW lamp is lighted.

The occurrence of resonant charge produces a surge of voltage on the plate monitoring line, the magnitude of which is proportional to the number of Flash Units charging. The surge is shaped into a pulse by capacitor C1 and resistor R2 and injected into the grid of triode V2. If either of the two Flash Units should fail to resonant charge, the pulse on the grid of V2 would not be great enough to cause any action in the Resonant Charge Monitor Relay.

Thyratron Bias and Driver Pulses Monitoring

The problem of monitoring thyratron bias and driver pulses is a little more involved. Thyratron bias is monitored by V3 and V4, whose grid potentials are a function of the grid biases of each of the two 5C22 hydrogen thyratrons, which signals are additively mixed via mixing resistors. Resistors R4 and R5 are so adjusted that the voltage on the grid of V3 is sufficiently negative that its plate just *doesn't* conduct enough to hold in the Bias Low Monitor Relay, while the grid voltage of V4 is but slightly negative so that its plate current just *does* hold in the Bias High Monitor Relay. This condition brings about lighting of the green BIAS OK pilot lamp. If the negative voltage on the grid monitoring line becomes too low, the bias on the grid of V3 decreases to a point where its plate current actuates the Bias Low Monitor Relay, causing the green pilot lamp to extinguish and the left-hand red BIAS LOW pilot lamp to light. If the voltage on the grid monitoring line becomes too highly negative, the plate current drops and causes the Bias High Monitor Relay to release, in which case the right-hand BIAS HIGH pilot lamp lights.

The action of monitoring of driver pulses from the grid monitoring line is identical to that of the resonant charge monitoring. The combined signals from the 2 L-R Monitoring Units are amplified by V5 and cause latching of the Driver Pulse Monitor Relay. If either of the two flash units being monitored fail to receive driver pulses, the amplified signal through V5 is insufficient to actuate the monitoring relay.

Electronically-Simulated Firing

To simulate the passage of a model through the Laboratory, 6-watt lamps placed within the field of view of

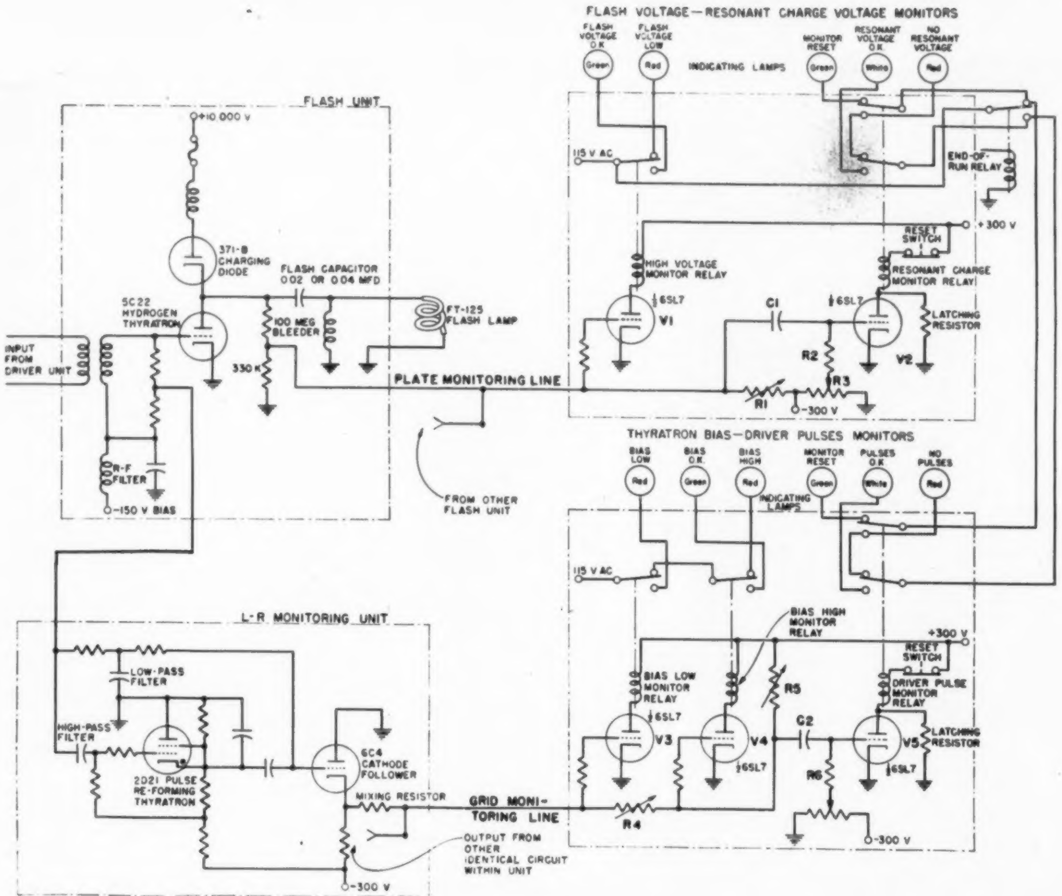


Fig. 10. Flash-unit monitoring system.

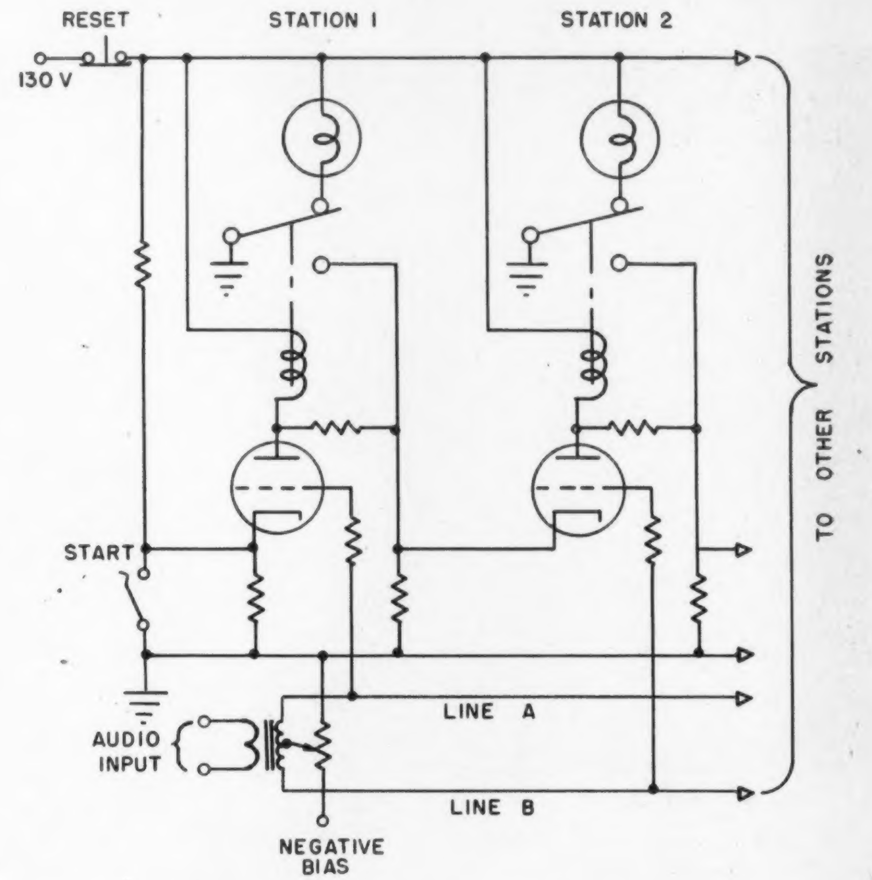


Fig. 11. Simplified circuit diagram of the projectile simulator.

the phototubes in the Stations are turned off in rapid succession down the Laboratory. All the electronic equipment of all Stations behaves exactly as though a missile model had been launched, giving a dynamic check on everything but the Light Screens and their monitoring circuits. (A check on these can be performed by slightly raising and lowering the Light Screen voltage.)

The unit which initiates the successive turn-offs is called the *Projectile Simulator Unit* (Fig. 11). The output of an audio oscillator, converted to push-pull by a transformer, is connected in-phase to the grids of all odd-numbered triodes, and out-of-phase to all even-numbered ones. The grids are biased negatively to a value slightly greater than the peak voltage of the audio. The cathode of each triode is held strongly positive by a voltage divider involving the relay of the previous stage so that, when all is ready to operate, no triode can conduct. Operation is initiated by closure of the START switch, grounding the cathode of the first triode. Near the positive peak of the audio voltage on line A, the first triode draws enough plate current to actuate its relay, an action which extinguishes the first lamp, latches the first relay in, and grounds the cathode of the second triode. Half of the audio period later, when the audio voltage on line B is near its positive peak, the second triode draws enough plate current to actuate its relay, extinguishing the second lamp, latching in the second relay, and grounding the cathode of the third triode. Thus, on alternate half-cycles of the audio frequency, successive triodes conduct momentarily, relays are actuated, and lamps are extinguished throughout the twenty-three Stations of the Laboratory.

Control of Missile Launching

The apparatus directly concerned with the control of missile launching is largely situated in the small racks under the top turrets in the Control Console. The principal function of the fourteen push buttons and the twenty-seven pilot lamps on the center panel is that of initiating, directing, and monitoring the equipment directly associated with this function.

A block diagram of the main elements of the control system for missile launching is given in Fig. 12. This is a greatly simplified version, each block representing a number of components and each interconnecting line representing perhaps several conductors.

The sequence of events taking place during operation of the laboratory, whether in simulated firing, actual firing, or single flash, is directed by switches controlled by a series of electric-motor-driven cams. After the sequence is started, there is no direct manual control. The sequence provides:

a. Sounding the warning device three times

b. Opening the camera shutters

c. Initiating whatever function is selected

d. Closing the camera shutters and actuating the end-of-run relay. Operation of the reset switch provides simultaneously:

a. Rotating of the sequence cam shaft back to the "ready" position

b. Releasing the end-of-run relay

c. Resetting the simulator or single flash, as required

d. Resetting all station gates and all monitoring relays, as required

Master Timing System

The Master Timing System can be described briefly as a 120-kc crystal oscillator followed by a series of binary count-down circuits feeding multiple driver amplifiers. These count-down circuits are manually switched into various feedback combinations to afford precise timing signals at various audio frequencies. The equipment presents two measurement problems:

a. It must be ascertained that the crystal oscillator is operating at 120 kilocycles per second to the accuracy required, and

b. The count-down circuits must be functioning properly to give the correct frequency division.

The second problem is solved by feeding one channel of the output of the system into one of the commercially available frequency counters for direct measurement of frequency. The same instrument can be used to solve the first problem after a harmonic of the instrument's own standard oscillator is zero-beat against WWV.

Flash Count System

For the photographic data to have its fullest utility, there must be unquestionable time correlation between any particular image on the photographic plates exposed at any particular Station and any other desired image on the plates at another Station. For this purpose, the

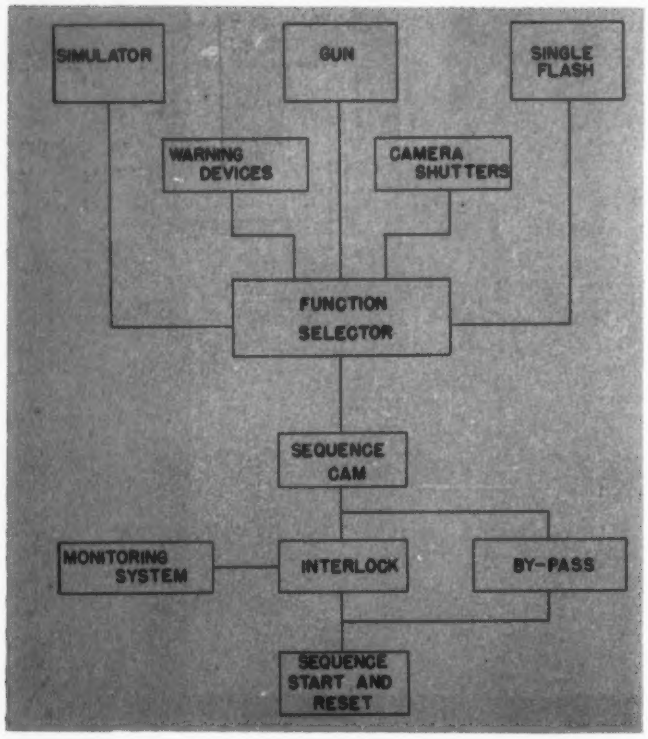


Fig. 12. Control system for missile launching.

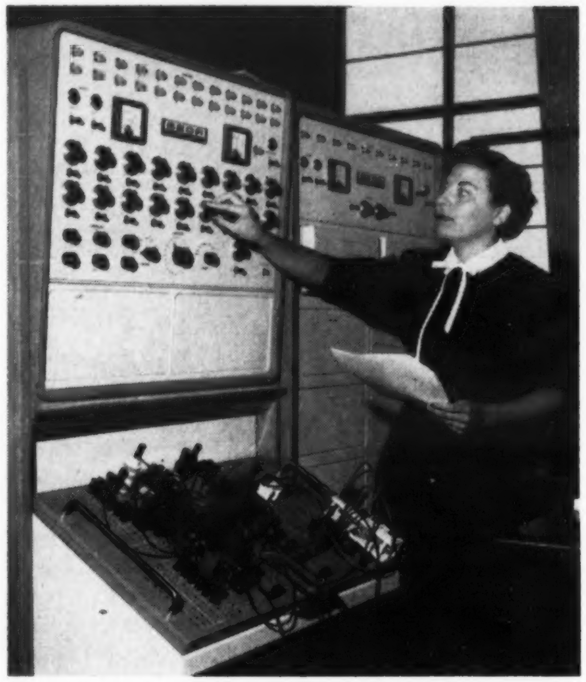


Fig. 13. Preliminary results and initial condition determinations are reduced from data on the Goodyear Aircraft GEDA analog computer. (Official United States Navy Photograph.)


Fig. 14. Final reduction of aeroballistics data is by IBM 701 digital computer. (Official United States Navy Photograph.)

Flash Count System is used. Here, a dual-decade counter with gate is supplied for every Station but the first. Several spare output lines from the Master Timing System furnish the first flash in the first station. The pulse which produces the first flash in the first station initiates the opening of all the Flash Count gates. The pulse which produces the first flash in each succeeding Station closes the Flash Count gate of that Station. Each Counter indicates the number of flashes that have occurred between the gating of the first Station and its own Station. As a safety precaution, provision is made that if the first Station fails to open the gates, the second may do so, and if the first and second fail, the third may do so.

Full-scale operation has proven the NOTS Aeroballistics Laboratory to be a practical facility as concerns its instrumentation and has also emphasized the great convenience of remote control and monitoring.

Results

The images recorded by the ballistics cameras are silhouettes of the missile produced against the illuminated background. Extensive research has shown that the illumination of the object against a dark background does not give satisfactory results. For this reason, the method of multiple-image silhouette photography was developed.

The flash lamps at the cameras produce brilliant illumination of a background of Scotchlite reflex reflective sheeting. Against this, the edges of the missile stand out clearly, and the photographic image has sufficient density to permit accurate measurements.

Two fiducial-mark projectors, each of which projects a 0.001-inch "dot" of light upon the photographic plate, provide an accurate means of relating the geometry of camera and plate. These fiducial marks serve as reference points when measurements are made on the developed photographic plate.

Comparator readings of plates from the ballistics cameras translate the flight record of a missile into numerical values. Measurements are made of the positions of specified points on the model with reference to a line joining the centers of the fiducial marks. Data of this kind from a pair of cameras are sufficient to determine (1) center-of-gravity position versus time, and (2) orientation versus time.

Data are then reduced on an electronic analog computer (Fig. 13), a Goodyear GEDA with 24 amplifiers 10 diodes, and 3 limiters. This technique provides the initial condition determinations necessary to digital computer reductions. At the same time, preliminary but reasonably accurate values of the aeroballistic coefficients are obtained.

The ease in programming of the analog computer makes possible rapid data reduction when the governing equations of motion are other than those for which the digital machine is already encoded. Nonlinearities due to large angles of attack and transients due to the actions of control surfaces can be handled in this way.

The reduction of aeroballistics data is performed by IBM 701 digital computer equipment with 800,000-word magnetic tape storage, 8,192-word drum storage, and 2,048-word electrostatic storage (Fig. 14). Comparator plate readings expressing the data from a flight are transferred to punch cards, which supply the information to the IBM calculator coded to calculate center-of-gravity position and missile orientation.

These data are then further processed to provide the aerodynamic derivatives of interest, including a measure of the accuracy of the final data. The calculator is encoded for the determination of drag, separating the component due to angle of attack, and of those force and moment coefficients which determine the yawing, pitching, rolling, and swerving motion of fin- and spin-stabilized missiles. The present encodings are based on linear equations of motion. All of the digital computer programs are double-precision.

End products of performance evaluation in the Aeroballistics Laboratory are the coefficients required for the design and development of the missile under test. These, expressed both in aerodynamic and ballistic nomenclature, include the following:

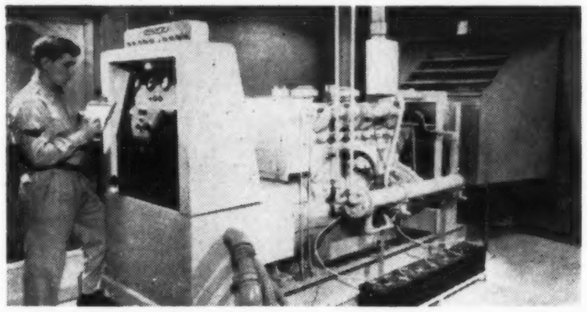
Coefficients	Aerodynamic	Ballistic
Drag	C_D	K_D
Normal force	C_{Na}	K_N
Pitching moment	C_{Ma}	K_M
Magnus moment	$C_{M_{Pa}}$	K_T
Magnus force	$C_{N_{Pa}}$	K_F
Yaw damping moment	C_{M_q} C_{M_a}	K_H
Spin deceleration (rolling) moment	C_{M_p}	K_A

(Arrangements for consultations or for the use of range facilities for research and developmental testing are initiated by communicating with the Commander, Attention Code 503, U. S. Naval Ordnance Test Station, China Lake, California. A description of the project should be given, together with information on security classification, priority rating, and other features that must be considered when time is being assigned for consultations or for the use of facilities.—Ed.)

Reference

1. E. Barofsky, R. Hopkins and S. Dorsey, "Microsecond Photography of Rockets in Flight," *Electronics*, June, 1953, p. 142.

Sage Power



Air Force technicians visit un-manned "gap-filler" radar sites periodically to observe and record operating characteristics of automatic power package.

Photo courtesy Consolidated Diesel Electric Corp.

COMPLETELY automatic diesel power plant thinks for itself—turns itself on and off, sends signals about operating conditions to technicians in a control center miles away, and operates without manpower in attendance. The plant has been developed for use in gap-filler radar stations in the SAGE continental radar system. Equipment features decision components and built-in memory system that records control or mechanical deficiencies or failures, and indicates to technicians at the control point what repairs are necessary and what parts need adjustment or replacement.

Examples of automatic operation of the twin diesel generator sets include:

1. Upon power failure the unit disconnects the load from the commercial power supply before taking over. This serves as protection against damaging equipment or feeding power from the unit into commercial power lines.

2. Both diesel generator sets are started simultaneously.

3. The first unit to reach full power output sends a signal to the second unit. The second unit then turns itself off and returns to standby condition ready to take over automatically in case of failure of the first unit.

4. The power plant makes an automatic two-hour check of the commercial power-supply voltage after this voltage has returned to the correct range. If the commercial voltage remains within established limits, the unit returns the radar equipment to commercial power, shuts itself off, and returns to standby condition.

This example of Military Automation frees personnel, allows the radar line to be operated with a minimum of trained technicians and decreases the chance of human error.

Milton H. Aronson
MILITARY AUTOMATION

and

Martin L. Klein
NORTH AMERICAN AVIATION, INC.

MODERN DIGITAL TECHNIQUES

A revolution is occurring in modern arithmetic, involving the substitution of an entirely new numbering system for the one that has been in use since antiquity. The "modern" way to measure, count, compute, and control no longer is based on the number 10—but rather on the number 2. The reason: modern automation devices using the binary system of 2 are much simpler than those based on the decimal 10. Here is an introduction to this new technique of digital automation, beginning a tutorial series on the subject.

WHY do we say that the number 789 follows the number 788? This progression is based on the fact that we accept the use of ten arithmetic marks—0, 1, 2, 3, 4, 5, 6, 7, 8, 9; and we increase the rightmost mark by one unit in counting.

Why do we say that 790 follows 789? This progression is based on the fact that when we have used up all the marks in one column (9 is the largest single mark), we move one column to the left and increase this by one mark while returning the rightmost mark (9) back to the first mark (0).

This same technique can be used for counting with any other number of marks. For example, if the human race had developed with four fingers instead of ten, we might be counting with the marks a, b, c, and d—and the counting progression could be as follows:

0	a
1	b
2	c
3	d
4	ba
5	bb
6	bc

Note that *any* decimal number would have an equivalent number in this 4-mark system.

Binary Code

Binary code uses only 2 marks. For convenience the marks are called 0 and 1. No other marks are used. These marks are called *bits,* a contraction of the words "binary digits."

Using the basic rules, what binary number follows 110?

We simply increase the rightmost mark to 111.

What number follows 11? Here we shift left until we can increase a column by a unit, as follows:

$$11 + 1 = 100.$$

Here again, *any* decimal number has its equivalent binary number, as shown in Table 1.

Why Use Binaries?

The advantage of binary arithmetic is twofold—(1) many devices are available which have two states and thus can be used to represent the two marks of the system, and (2) arithmetic by binaries is much simpler than by decimals. Thus, a computer using binaries to solve a problem is small and simple, whereas a computer using decimal

Table 1—Decimal Numbers and Binary Equivalents.

Decimal	Pure Binary
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1
10	1 0 1 0

Table 2—Powers of Common Number Systems

$2^0 = 1$	$8^0 = 1$	$10^0 = 1$
$2^1 = 2$	$8^1 = 8$	$10^1 = 10$
$2^2 = 4$	$8^2 = 64$	$10^2 = 100$
$2^3 = 8$	$8^3 = 512$	$10^3 = 1{,}000$
$2^4 = 16$	$8^4 = 4{,}096$	$10^4 = 10{,}000$
$2^5 = 32$	$8^5 = 32{,}768$	$10^5 = 100{,}000$
$2^6 = 64$	$8^6 = 262{,}144$	$10^6 = 1{,}000{,}000$
$2^7 = 128$	$8^7 = 2{,}097{,}152$	
$2^8 = 256$	$8^8 = 16{,}777{,}216$	
$2^9 = 512$		
$2^{10} = 1{,}024$		
$2^{11} = 2{,}048$		
$2^{12} = 4{,}096$		

Table 3—Radix of Common Number Systems

System	Marks Commonly Used	Radix
Decimal	0, 1, 2, 3, 4, 5, 6, 7, 8, 9	10
Binary	0, 1	2
Trinary	0, 1, 2	3
Octal	0, 1, 2, 3, 4, 5, 6, 7	8

Table 4—Binary-Coded Decimal Readout

$0 = 0$
$1 = 1$
$2 = 2$
$3 = 2 + 1$
$4 = 4$
$5 = 4 + 1$
$6 = 4 + 2$
$7 = 4 + 2 + 1$
$8 = 8$
$9 = 8 + 1$

technique for the same problem would be much more complicated.

Binary is perhaps the easiest set of numbers with which to perform arithmetic. For example, addition is performed by only two simple rules:

Rule 1: 0 plus 1 is 1
Rule 2: 1 plus 1 is 0 and carry 1 to the next column left.

Let us use these rules to add the numbers 10 (equivalent to decimal 2) and 11 (equivalent to decimal 3).

```
 10
 11
 --
  1
 0    carry 1 left
 1    the carried number
---
101   (equivalent to decimal number 5)
```

When performing arithmetic by decimals, it is necessary to remember (or build a computer element that remembers) many rules: 2 and 3 are 5, 2 and 4 are 6, etc., etc. Contrast this with the two simple rules of binary arithmetic. The complete simplicity of performing arithmetic with binaries is the reason why it is being expanded into so many automatic measurement and control situations.

Multiplication

Multiplication is but a simple extension of addition, and again only 2 rules are required for binary multiplication:

Rule 1: 1 x 0 is 0
Rule 2: 1 x 1 is 1

Using these two rules, let us multiply the two numbers 10 (or 2) and 11 (or 3).

```
 10
 11
 --
 10
10
---
110   (Equivalent to decimal 6)
```

Here again, note the complete simplicity, and the lack of necessity for remembering that 2 times 3 is 6, or 2 times 4 is 8, etc., etc. It is necessary to remember *only* that 1 x 0 is 0 and that 1 x 1 is 1.

Converting Binaries to Decimal

Even though binary arithmetic is much simpler then decimal arithmetic, our thought processes are, by habit, decimal in nature—and thus we must be able to convert the binary number to a decimal number. The conventional manner in which this is done is by using the concept of "powers." In decimals, each column place is a power of ten—that is, the number 49 means 40 + 9, which means $4(10)^1 + 9(10)^0 = 49$.

Similarly, the decimal number 3742 means

$$3000 + 700 + 40 + 2$$
$$= 3(10)^3 + 7(10)^2 + 4(10)^1 + 2(10)^0$$
$$= 3742$$

Table 5—Binary-Coded Decimal Notation

Decimal	Binary-coded Decimal
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	0001 0000
11	0001 0001
12	0001 0010
13	0001 0011
14	0001 0100
15	0001 0101
16	0001 0110
17	0001 0111
18	0001 1000
19	0001 1001
20	0010 0000

Table 6—Sexadecimal Notation

Decimal	Binary	Sexadecimal
0	0	0
1	1	1
2	10	2
3	11	3
4	100	4
5	101	5
6	110	6
7	111	7
8	1000	8
9	1001	9
10	1010	u
11	1011	v
12	1100	w
13	1101	x
14	1110	y
15	1111	z
16	10000	10
17	10001	11
18	10010	12
19	10011	13
20	10100	14

Thus, each column represents an implied power of 10.

Similarly, in the binary system, each column represents an implied power of 2. Thus, the number 1110011 means

$$1(2)^6 + 1(2)^5 + 1(2)^4 + 0(2)^3 +$$
$$0(2)^2 + 1(2)^1 + 1(2)^0$$
$$= 64 + 32 + 16 + 0 + 0 + 2 + 1$$
$$= 115.$$

Note that each column in a binary system represents a power of 2, just as each column in the decimal system represents a power of 10.

Systems other than 2 and 10 are in use for special purposes. As all numbers up to 8 can be represented by three binary marks,

0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111

a 3-mark system is used often where only 8 variables enter a problem. When counting in an octal system, the largest numeral is 7, and the next number (corresponding to decimal 8) is 10. Note here that each "place" in the octal system represents a power of 8. To facilitate conversion of binaries to decimal, a table of powers of common number systems is given in Table 2. The base of each system is called a *radix,* and the radix of common number systems is given in Table 3.

The Double-Dabble System

A techique for binary-to-decimal conversion that is more rapid than conventional addition of each power of 2 has been developed by Edward Varnum (Barber-Colman Company) and Robert Brooks (Computer Control Company). This system, called the *double-dabble system,* starts with the leftmost bit and proceeds as follows:

If the next bit is 0, *double* what you have.

If the next bit is 1, double what you have and add 1, which is called *dabbling.*

Let us convert the binary 1101 by double-dabble:

Starting at the left, first dabble 1 to get 3 because the next bit is 1; then double 3 to get 6; then dabble 6 to get 13. (As 1101 is 8 plus 4 plus 1, it is indeed 13.)

Conversely, to convert a decimal to a binary, the following technique is used:

First, divide the number by 2 and write down the remainder (which must be either 0 or 1).

Second, divide the new number by 2 and write down the remainder. All the remainders describe the binary equivalent. For example: let us convert the decimal 27:

$27/2 = 13$ remainder 1, write 1
$13/2 = 6$ remainder 1, giving 11
$6/2 = 3$ remainder 0, giving 110
$3/2 = 1$ remainder 1, giving 1101
$1/2 = 0$ remainder 1, giving 11011
Thus $27 = 11011$

Binary-Coded Decimal

The binary-coded decimal system uses binary devices to indicate the decimal number directly. This is done simply by letting each digit in the decimal number be represented by a 4-bit binary number, as follows:

10=0001 0000
22=0010 0010
863=1000 0110 0011

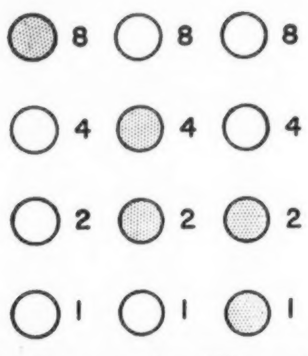


Fig. 1. The binary number 863 can be expressed in binary-coded decimal as 1000 0110 0011, and can be indicated by lights as shown here.

Note that four bits are needed to express any single decimal digit because the largest decimal number (9) is 1001 in binary. Hence, four bits are needed in binary-coded decimal, and the number is a set of 4-bit binaries, as shown in Table 5.

Binary-coded decimal is used often as the input or output of a computer that works with binary numbers internally, but which uses decimal input and output for convenience.

A common readout device uses rows of 4 lights to indicate decimal numbers in binary-coded-decimal manner. The number 863 is so shown in Fig. 1.

Sexadecimal Notation

Many equipments use 4-bit circuitry because they use binary-coded decimal notation on either the input or the output. However, 4 bits can express any decimal number up to 15 (1111). Thus the same circuitry can be used to express any of the 16 numbers between 0 and 15, and this *sexadecimal notation* is shown in Table 6.

Table 7—Cyclic Notation

Decimal	Pure Binary	Cyclic
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101

Table 8—Common Coded Notations

Decimal	Pure Binary	Cyclic	Binary-Coded Decimal	Sexadecimal	1, 2, 4, 7	Excess 3
0	0000	0000	0000	0	0000	0011
1	0001	0001	0001	1	0001	0100
2	0010	0011	0010	2	0010	0101
3	0011	0010	0011	3	0011	0110
4	0100	0110	0100	4	0100	0111
5	0101	0111	0101	5	0101	1000
6	0110	0101	0110	6	0110	1001
7	0111	0100	0111	7	1000	1010
8	1000	1100	1000	8	1001	1011
9	1001	1101	1001	9	1010	1100
10	1010	1111	0001 0000	u	1100	1101
11	1011	1110	0001 0001	v	10001	1110
12	1100	1010	0001 0010	w	10010	1111
13	1101	1011	0001 0011	x	10100	10000
14	1110	1001	0001 0100	y	11000	10001
15	1111	1000	0001 0101	z	100000	10010
16	10000	11000	0001 0110	10	100001	10011
17	10001	11001	0001 0111	11	100010	10100

Cyclic Coding

Another widely used coding technique is based on the fact that errors are reduced if only one bit at a time changes as we progress from one number to the next. For example, in ordinary binary code the number following 0111 is 1000— Note that four bits had to change, and hence an error in operation could mean that the answer might be any number between 0000 or 1111, which is 16 different numbers. This dangerous situation is made impossible by using a code in which only one bit changes at a time, as shown in Table 7.

Cyclic, or Gray, coding can be obtained from straight binary, or vice versa, by a simple technique: To progress from the number in binary to its cyclic equivalent, we add the binary number to itself without carrying; before adding, the number is indexed one place to the right, Thus, if we go from binary 111 (which is decimal 7) to the cyclic number code for 7 we perform the following addition:

$$\begin{array}{rl} 111 & \\ 11 & (1) \\ \hline 100 & \text{(Do not carry)} \end{array}$$

Excess 3 Code

This notation, shown in Table 8, is used to simplify the subtraction process. It is the same as pure binary except that each number is the binary number plus three (011). In Excess 3 binary, the 0 and 9 are identical opposites—that is, the 0 replaces the 1, and the 1 replaces each 0. Similarly for the numbers 3 and 6, 2 and 7, 4 and 5. In other words, 9 minus any number is the same as the number except for the interchanging of 0's and 1's. This facilitates complementing and substraction in computing.

1, 2, 4, 7 System

The 1, 2, 4, 7 system (or 7 4 2 1 system) has the advantage that only two 1's are used to express any number. Note that after number 6 is reached, another column is used to attain number 7, rather than using three 1's. Hence the code is called 1, 2, 4, 7 to distinguish it from the conventional binary code, which is a 1, 2, 4, and 8 code.

Floating Decimal Point

Floating decimal point is a short cut that can be used for either longhand or computer arithmetic. This expresses the number with significant figures times a multiplier expressed exponentially. For example, to multiply 1200 x 1200, we can multiply $(1.2)(10^3) \times (1.2)(10^3)$, and obtain $1.44(10^6)$, which is 1,440,000. This "floating decimal point" technique involves multiplying all numbers other than 10 and adding the exponents of 10. It saves the adding up of a lot of columns, as in conventional multiplication.

In our next installment we meet a few simple-minded "electrobots" who can perform simple digital computation—(Ed.)

Supersonic Tunnel Has Automatic Data Readout

ANALOG-TO-DIGITAL conversion techniques are getting a real workout in new transonic and supersonic wind tunnels of United Aircraft Corp. at company's East Hartford testing laboratories. These new tunnels, designed to simulate flight conditions at Mach 0.5 to 1.5 and Mach 1.5 to 5.0 respectively, are expected to speed up research in design of aircraft components by using new high-speed data gathering equipment (Fig. 1).

The tunnels are of the "blowdown type"; instead of a compressor operating continuously at high speeds, a much smaller compressor builds up a storage supply of compressed air released through an automatically controlled valve to provide a regulated high-speed air flow lasting 10 to 60 seconds.

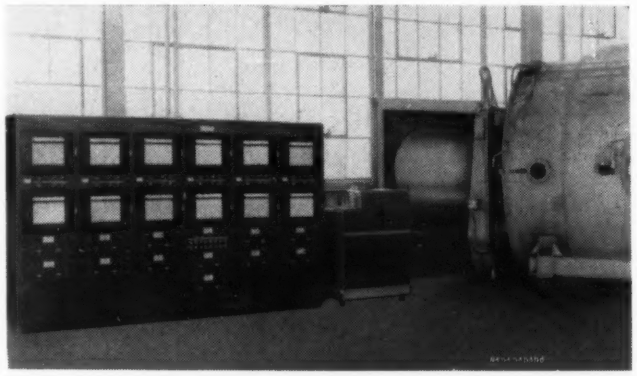


Fig. 1. Array of recording potentiometers provides continuous record of forces on model in supersonic wind tunnel. Summary card punch at center receives test data after conversion to digital form by encoders.

Various forces acting on the model under test are detected with strain gauge pickups. Output is measured and continuously recorded by high-speed, recording, self-balancing* potentiometers (Bristol Dynamasters). Encoders convert angular position of potentiometer shafts into digital information, which is fed into a summary card punch. Fig. 2 shows schematic of the entire system, which was designed by Giannini DATEX.

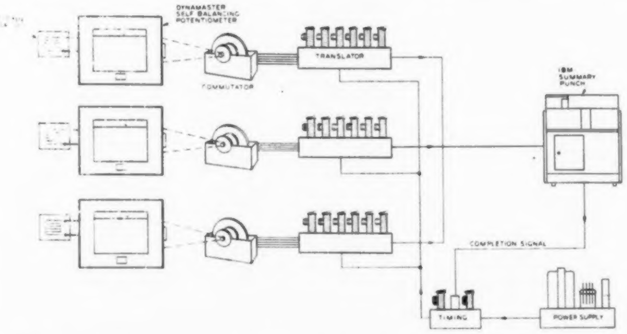


Fig. 2. Progression of intelligence starts from force-sensing strain gages at left through digitizers to punched-card record.

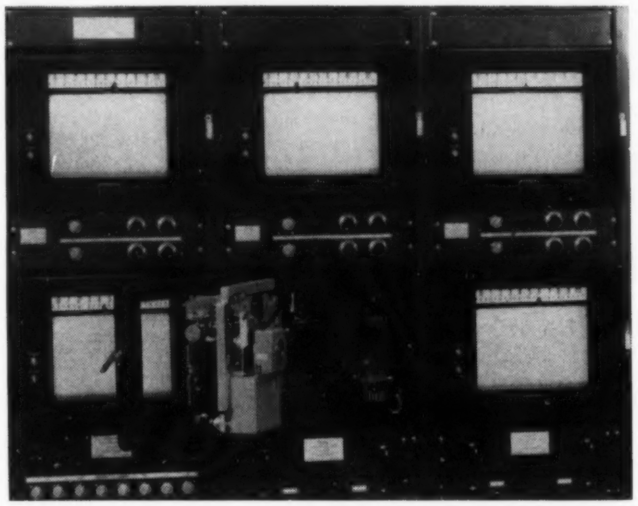


Fig. 3. Encoder mounted directly behind potentiometer converts 336° angular rotation of potentiometer shaft into 100 discrete digits.

Constants of the test, such as date, ambient temperature, barometric pressure, geometry of the test sample, etc., are set on 16 dials (center of panel shown in Fig. 1) and also fed to the card punch, which operates at a rate of 100 cards per minute (IBM). Cards are analyzed and tabulated by United's data reduction section. The continuous potentiometer records provide information on reactions between card punch operations providing an added safeguard in evaluating the tests.

The potentiometer and encoder component (Fig. 3) can be used to measure and convert speed, pH, smoke density, resistance, capacitance, power, viscosity, etc., when used with suitable primary measuring devices. Each potentiometer is equipped with precision resistors which can shift the zero or expand the scale so that output from any given pickup will give full-scale response at its maximum output. This gives a uniform trace on all charts, and makes analysis easier.

The system can be equipped to feed its digital information directly into an automatic typewriter, teletype transmitter, or other digital handling equipment, as well as into a card punch machine. The information can be stored for later analysis or used directly by computers.

*A self-balancing potentiometer is basically a servomechanism which will drive a recorder or will provide a mechanical or electrical output proportional to an input voltage or current.

125 Miles Up

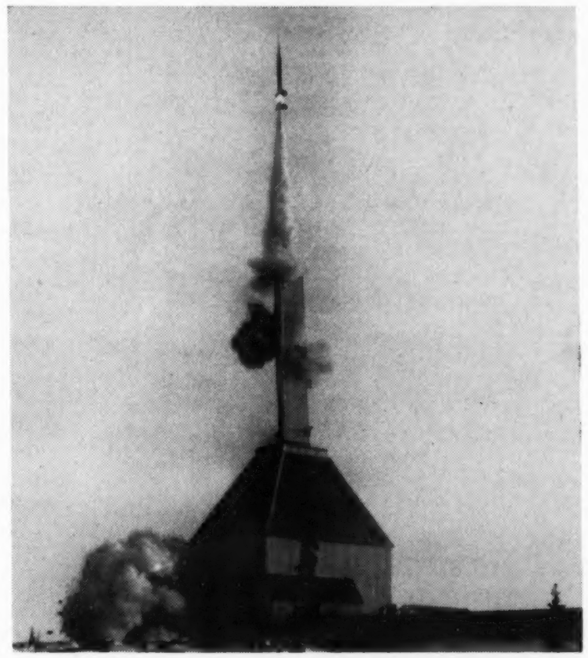


Fig. 1. Navy Aerobee-Hi launching.

AN Aerobee-Hi rocket was launched recently (Fig. 1) by the Naval Research Laboratory of Washington, D. C., in preparation for the United States program of rocketry for upper atmosphere research during the International Geophysical Year. It reached an altitude of 125 miles, and a speed more than a mile per second. A Decker T-42 Ionization Transducer system provided continuous and accurate measurements of both ram and ambient atmospheric pressures with an output of over 1 volt per 0.005 psia. This is the first time an extensive pressure measurement system has been completely contained within the pitot static tube.

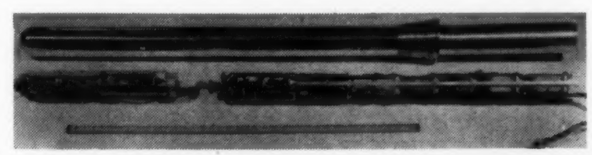


Fig. 2. Pitot Static Tube housing (top) weighs 23 pounds. Instrument pickups weigh 26 ounces and associated circuitry 5 pounds.

Photos courtesy Naval Research and Decker Aviation Corp.

The Analog Computer

Robert L. Yeager
Electronic Associates, Inc.

THE TERM "analog" is derived from the word analogy, which means "similarity" or "resemblance." The analog computer creates electrical facsimiles or "analogs" of physical phenomena. The dynamic characteristics of the simulated system can be investigated thoroughly on the computer before the first test or prototype model is ever built. The net result—economy in technical manpower and a superior product.

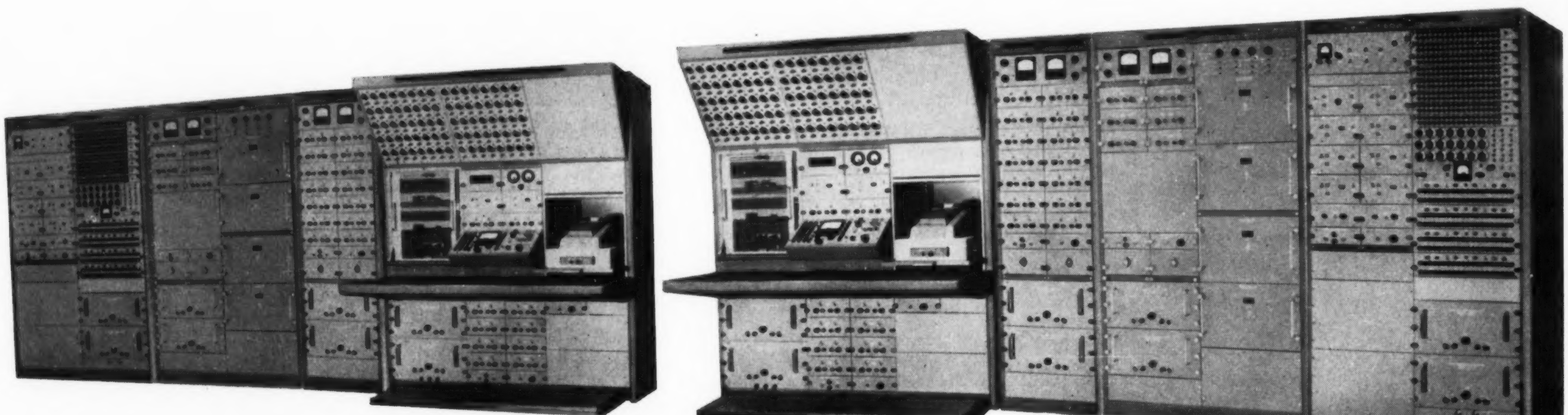


Fig. 1. Typical general-purpose, indirect, analog computing facility.

It is possible today to fly a plane, drive a tank, aim a gun, or track a missile without handling or even building the plane, tank, gun or missile. It is fitting that this first issue of MILITARY AUTOMATION, a magazine devoted to the new technologies of our times, contain an introduction to the analog computer, the device that makes possible the simulation of an entire system. It is fitting, also, that MILITARY AUTOMATION extend this recognition to analog computation because it is the military that has supported the development of the analog computer to its present position of availability. Analog computation and simulation is one of the basic new technologies of our times; it is destined to become a key technique in every phase of modern technology. This begins a series of tutorial articles on analog computation and simulation.

The technique of utilizing both electrical and mechanical models or analogs for certain types of problem solution has been known for many years. The development of the electronic analog computer, however, has achieved rapid strides only in the years following World War II. Credit for this development appears to accrue to C. A. Lovell and D. B. Parkinson of Bell Telephone Laboratories, who utilized operational-amplifier computing techniques in the computer of the M-9 anti-aircraft gun director (built by Western Electric Company for use in World War II). The use of these circuits was noted by other engineers, and in 1947 a number of companies began independent development of analog-computing machines and techniques. Thus, in less than ten years, a new and formidable approach to engineering design has evolved —an approach that is effecting inestimable savings in engineering manpower, for both Government and industry alike.

Major Types

The analog computers in use today may be categorized into two broad divisions—(1) *special purpose* and (2) *general purpose*. Special-purpose analog computers are designed and built to solve one particular problem. General-purpose analog computers, however, are flexible research tools—versatile enough, with the proper complement of equipment, to be utilized in virtually unlimited applications. As shown in Fig. 2, the general-purpose machine can be further categorized according to its method of operation—that is, *direct* or *indirect*.

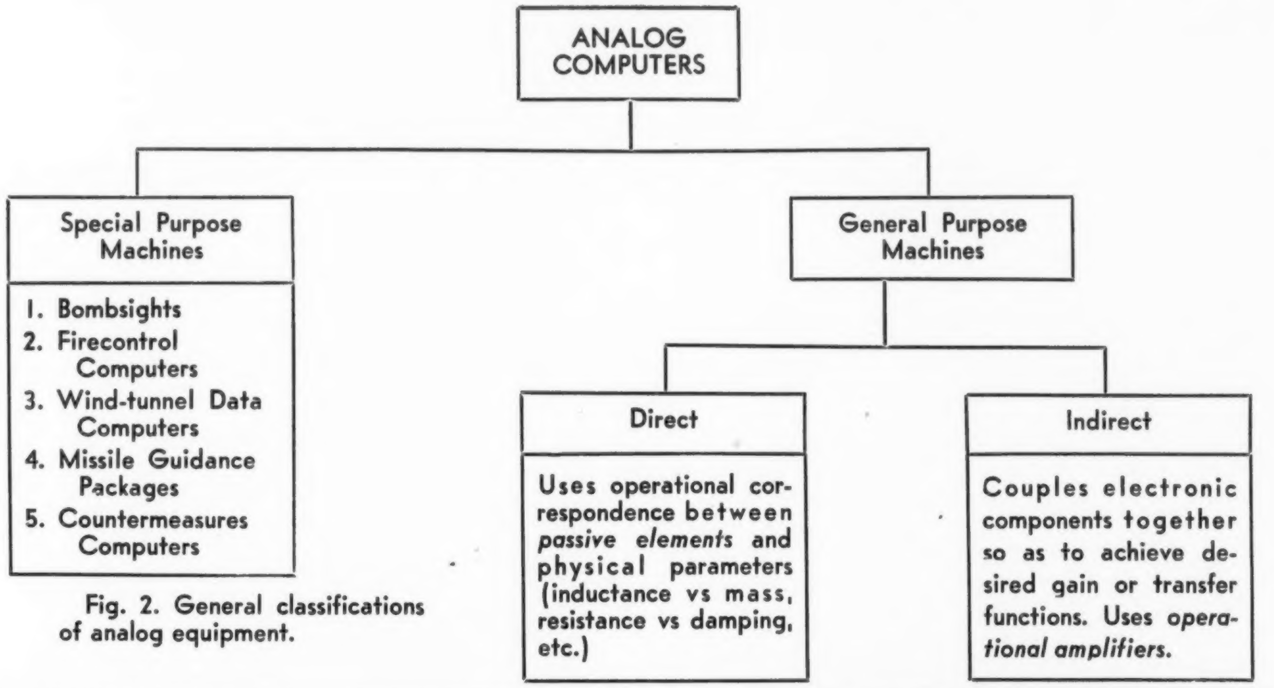


Fig. 2. General classifications of analog equipment.

General-Purpose Direct Types

The direct type utilizes the direct operational correspondence between certain electrical passive elements and corresponding physical parameters. For example, Fig. 3 shows an R, L, C circuit that represents the electrical analog of a damped-spring suspension system.

The x equation for the physical system is:

$$M\ddot{x} + B\dot{x} + Kx = f(t)$$

The q equation for the electrical system is:

$$L\ddot{q} + R\dot{q} + q/C = f(t)$$

Note the direct operational correspondence between mass and inductance, between resistance and damping factor, and between reciprocal of capacitance and spring constant.

Direct analogs have been used for years, but have never achieved widespread favor because of high cost and unavailability of perfect components. That is, the resistance always found in inductance and vice versa, the leakage experienced in all capacitors, etc., introduce errors.

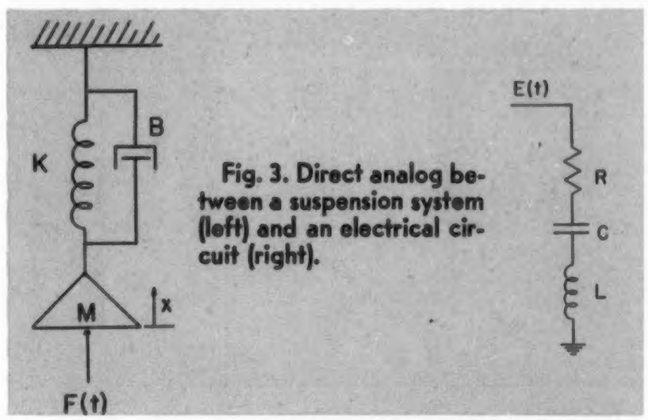


Fig. 3. Direct analog between a suspension system (left) and an electrical circuit (right).

General-Purpose Indirect Types

The indirect-type general-purpose machine, or mathematical analog computer, uses the ability of the computer to express certain mathematical relationships. One of the best known mechanical indirect analogy machines is the slide rule, on which lengths of the stick are analogous to numbers.

The type of indirect machine that has contributed more significantly than any other to the advance of military design is the *electronic general-purpose analog computer*, commonly known as the *electronic differential analyzer*. A typical expanded computer system of this type is shown in Fig. 1. As this computer is typical of a large number of available equipments, a knowledge of its elements and operation serves to introduce the entire field.

The Patch Panel

The electronic general-purpose analog computer is equipped with computing components that are built to perform certain mathematical operations—for example,

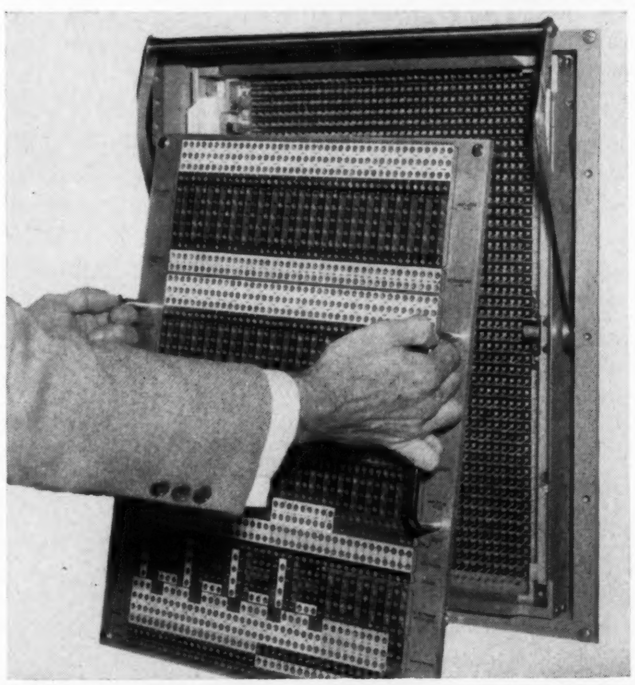


Fig. 4. Patch panel is removable from machine so that programming need not use computer time.

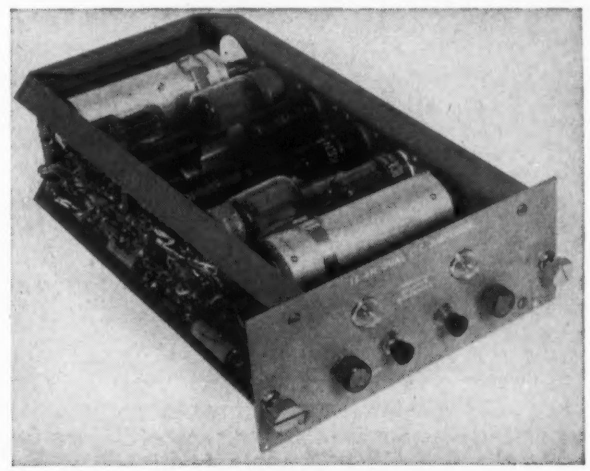


Fig. 5. Amplifier chassis.

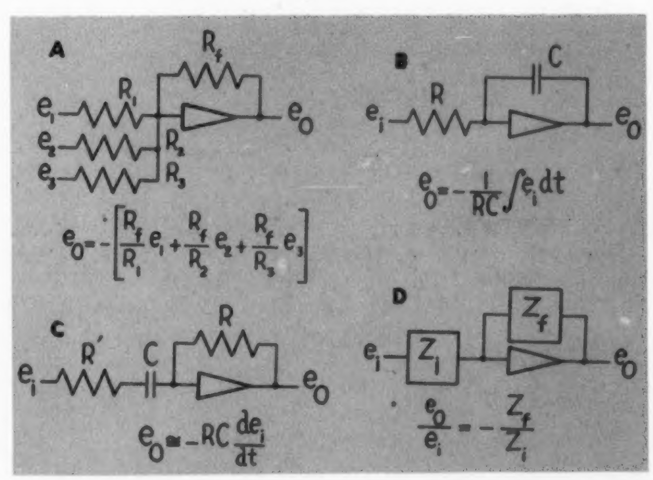


Fig. 6. Operational amplifier (represented by triangle) is converted into summing amplifier at A, integrator at B, differentiator at C, and any operational element at D, by various feedback arrangements.

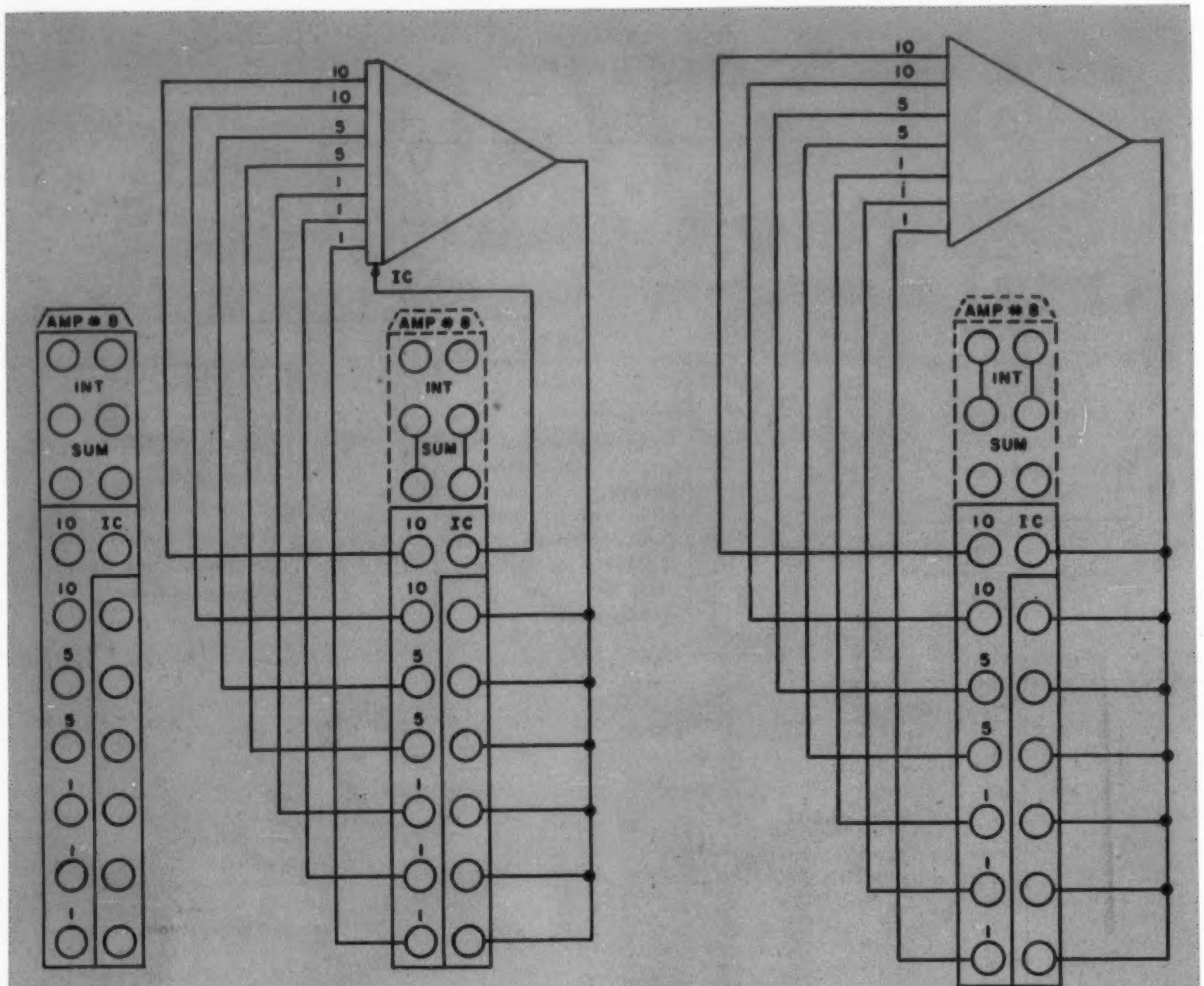


Fig. 7. Combination amplifier appears on patch panel as at left. Bottle plug inserted in 2nd and 3rd row covers word SUM and exposes INT, connecting amplifier as integrator as shown in center (with integrator symbol at top). Bottle plug in top four holes connects amplifier internally as summing amplifier, and exposes SUM on patch panel, as shown at right (summing amplifier symbol at top). Numbers on terminals describe gain for that particular connection.

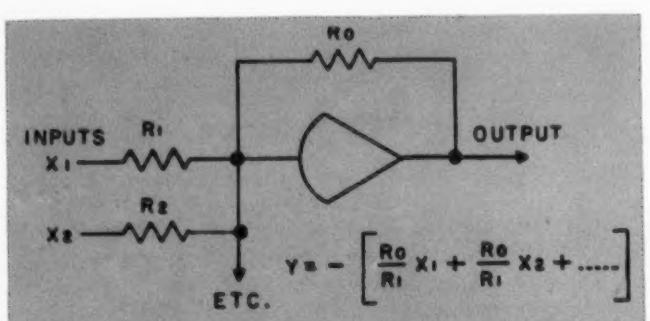
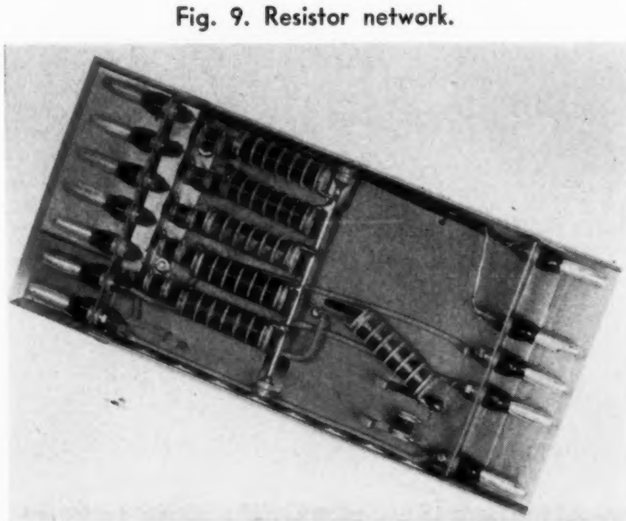


Fig. 8. Standard summing amplifier with 5 inputs.

Fig. 9. Resistor network.



multipliers, adders, integrators, etc., are built into the equipment. The inputs and outputs of these operational components are made available at the *patch panel* of the computer system. The various operational components can be assembled into the desired circuit arrangements simply by "patching," or inserting jumpers into the holes of the patch panel. The patch panel is arranged so that it may be patched or programmed while away from the computer so that computation may be taking place on one problem while programming is taking place on another. A typical patch panel, capable of terminating a wide variety of general-purpose computer components is shown in Fig. 4.

Operational Amplifiers

The fundamental building block of the electronic differential analyzer is the *d-c amplifier*. The term "*operational amplifier*" is a generic description of those amplifiers which use various types of feedback in order to perform various desired operations, such as summation, inversion, differentiation and integration. The specifications required of the computing amplifier are high open-loop gain (usually on the order of 10^8), low drift (accomplished normally by chopper stabilization), good frequency response (flat to about 20 kc), and negligible input grid current (60 microamperes or less). A typical computing amplifier chassis is shown in Fig. 5.

Fig. 6A shows one of these amplifiers operating in the summing mode, B shows hookup for integration, C shows differentiation,* and D, inversion.

Patch-panel terminations for an amplifier that can operate as either a summer or an integrator are shown in Fig. 7. The mode of operation is determined by insertion of a four-prong "bottle plug," which serves to connect either the feedback resistor or capacitor into the amplifier feedback circuit. When the bottle plug is placed in the top four holes, a one-megohm feedback resistor is connected from amplifier output to grid, and the amplifier operates as a summer. The word "sum" is exposed below the bottle plug, indicating the mode of amplifier operation. When the plug is placed in the bottom four holes, a one-microfarad capacitor is substituted in the feedback circuit and the amplifier operates as an integrator. The letters "INT" are then exposed above the bottle plug.

Thus, the mode of amplifier operation is actually determined at the patch panel, and the same amplifier that performs as a summer in one problem can operate as an integrator during a subsequent problem. Determining amplifier operating mode is one of the preliminary steps in programming.

Choice of the proper input resistor (Fig. 8) determines the gain factors that are applied to the inputs during either the summing or integrating mode of operation. These gains are indicated by the numbers above each input hole, as shown in Fig. 7.

*Integration is used more often than differentiation in simulating and solving problems because differentiation, by its nature, emphasizes high-frequency noise signals, whereas integration does the opposite.

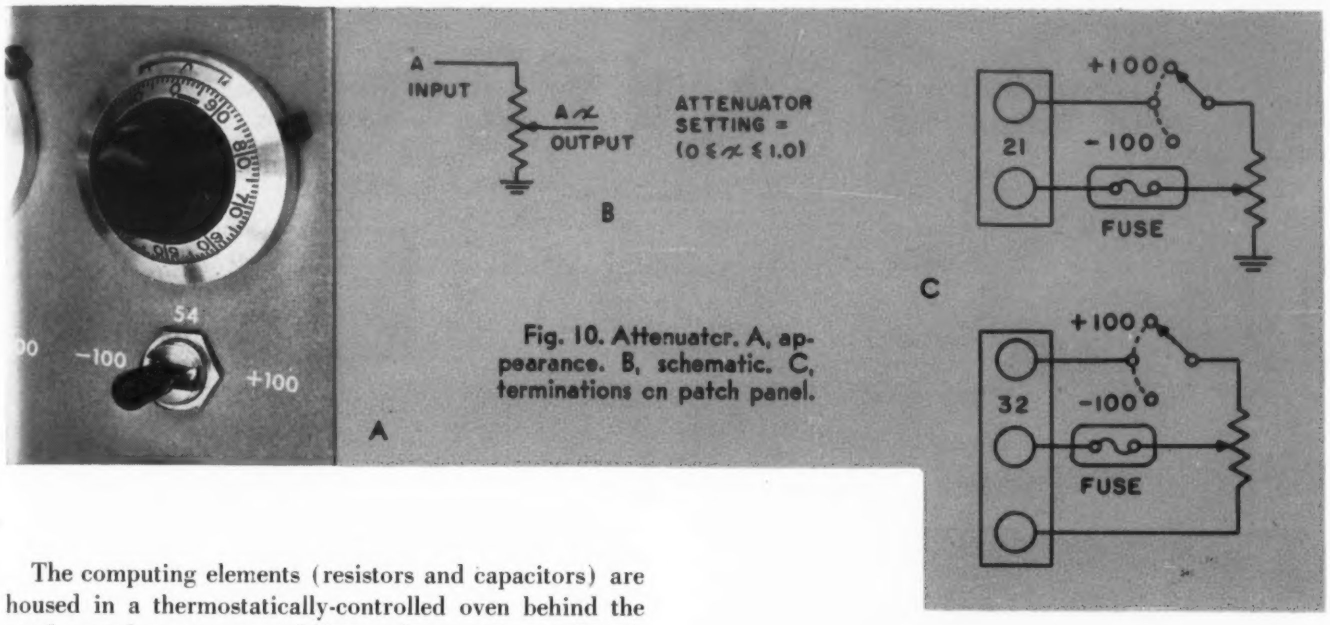


Fig. 10. Attenuator. A, appearance. B, schematic. C, terminations on patch panel.

The computing elements (resistors and capacitors) are housed in a thermostatically-controlled oven behind the patch panel to assure stability and accurate results. A typical resistor network is shown in Fig. 9.

Attenuators

A large number of attenuators (potentiometers) are required in simulation and are provided on the analog computer.

Attenuators are usually wired so that the bottom of the pot is grounded, while the top may be switched to the patch panel or to a highly-stable plus-or-minus voltage source (Fig. 10). The top of the pot and the wiper are brought to the patch panel as shown. A potentiometer input (A) will be attenuated and appear as wiper output Ax, with x the potentiometer setting.

A switch below each attenuator enables it to be connected to the plus or minus reference supply; this reduces the number of patch cords used and the time required to patch problems. Fig. 10 shows the patch-panel terminations for a typical attenuator. Occasionally it is desirable to apply a voltage to the bottom of an attenuator as well as to the top. Therefore, a few attenuators are connected as shown at lower right in Fig. 10C.

Amplifiers and attenuators are commonly referred to as the *linear components*, and are all that is required for solution of systems of *linear differential equations with constant coefficients*. Although a large number of dynamic systems can be defined by these components alone, a great many phenomena contain nonlinearities that call for the multiplication of two variables, or the generation of a function of a single variable. Units performing these operations are known as *multipliers* and *function generators*, and are found in many types, shapes and sizes.

Multipliers

Many *electromechanical* multiplying devices are presently in use in the computer field and are giving adequate performance within a fairly limited dynamic range. The device, however, which seems to offer the greatest possibility of replacing these mechanical multipliers for accurate, high-speed computation is the *electronic stabilized time-division multiplier*. This all-electronic device operates on the principle that if one input variable modulates height and the other modulates width, of a series of 10-kc square waves, then the resulting energy level of the pulse train is proportional to the product of the two variables. A multiplier of this type, which can be expected to yield a typical static product accuracy of 0.01%, and an accuracy of 2% at 100 cps input, is shown in Fig. 11.

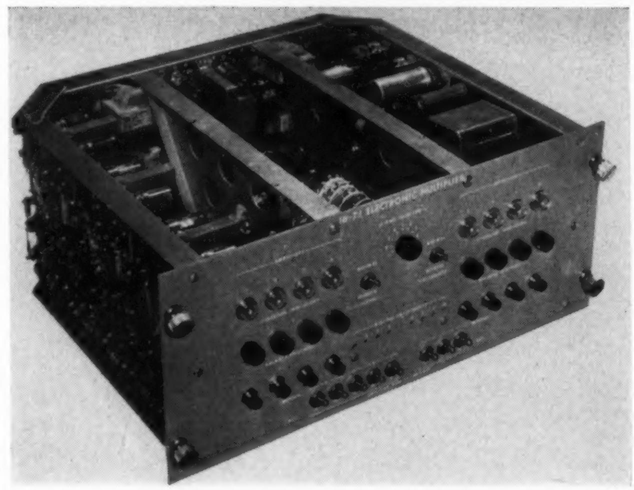


Fig. 11. Time-division electronic multiplier.

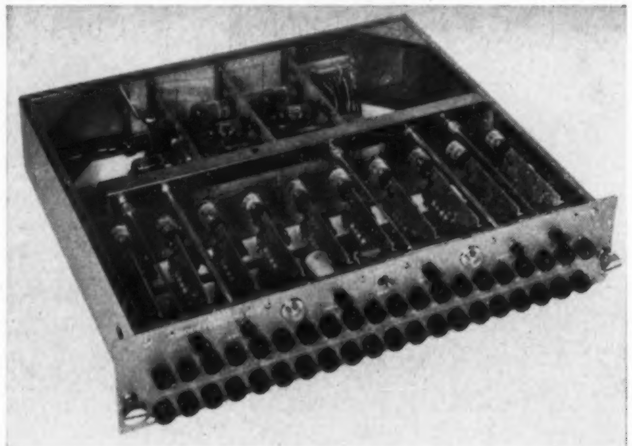
Function Generators

A popular device used for the generation of arbitrary functions of one (and in some cases more than one) variable is the electronic diode function-generator (DFG). Ease of setup, good frequency response, relatively low cost and good fidelity of reproduction are the important factors which have contributed to the widespread use of this computing component.

A typical DFG chassis is shown in Fig. 12. It is capa-

ble of representing an arbitrary function Y = F(x) with 20 straight-line segments, as shown in that figure.

Another advantage of this type of function generator is its ability to represent the extremely nonlinear portions of a curve by many short segments, and thereby



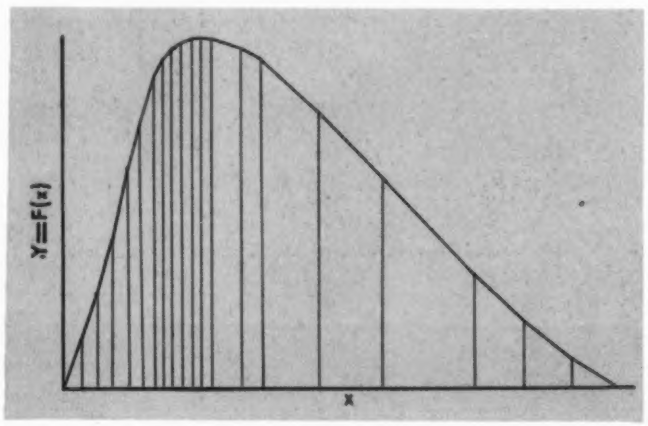


Fig. 12. Typical diode function-generator and typical output curve.

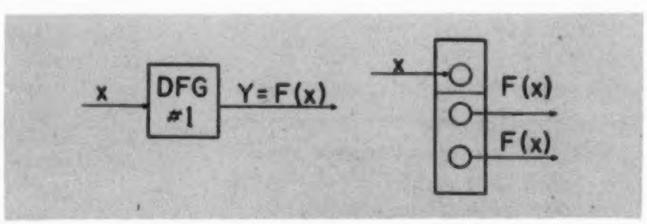


Fig. 13. Diode function-generator symbol and patch-panel terminations.

achieve a more accurate approximation of the function. The symbol and patch-panel terminations for this unit are shown in Fig. 13.

These two nonlinear computing devices by no means cover the field of nonlinearities that can be simulated. Quotients, roots, and exponentials can be obtained readily, and backlash, hysteresis and boundary conditions can be simulated with the use of other nonlinear equipment.

Now that we have introduced analog computing fundamentals and components, we are ready to investigate specific applications. (*To be continued in the next issue*).

Stockpiled Factories

WHOLE factories can be stockpiled, at strategic locations throughout the country, ready for instant set-up when needed. With standardized work centers that include their own lighting units, power facilities, and communication channels, production can literally be set up in tents if necessary.

Work-center system components are all standard prefabricated units, sectionalized so that one unit will build on the next. It is possible to build up lines to any desired length and arrange each work position in any desired way. Lines can be expanded or contracted at will.

A power facilities and communications channel, less than 3″ wide, makes it possible to tap in and get any type of power or communications (control) facility at each operator or machine position. These facilities can be electric power, refrigerant, steam, hot or cold water, gas, hydraulic line, air, rare gas, vacuum, exhaust flue, or anything that can be carried over a wired circuit or through a pipe line. The availability of these channels is the key to the flexibility of the system, designed by Alden Systems.

Defense experts see production set up from bare floor in 29 minutes. *Photo courtesy Alden Systems Co.*

Trial Setup

At a meeting of the Eastern Seaboard Defense Mobilization Council representatives of the Armed Services and various civilian government agencies saw a dramatic demonstration of rapid production setup. Starting from bare floor, a 4-position manufacturing operation, including lighting, power facilities and work positions was set up by a two-man team using only a socket wrench. In 29 minutes production was coming off the line.

The significance to people interested in defense security is that in like manner 20 men could set up a 1000-man factory in 12 hours.

MA EVENTS

February 15
22nd Meeting of the Gulf Coast Spectroscopic Group, Colonial Room. Sabine Hotel, Port Arthur, Texas. For information write W. J. Ruez, Program Chairman, Gulf Coast Spectroscopic Group, Petro-Tex Chemical Corp., P. O. Box 2584, Houston 1, Texas.

February 25-27
Military-Industrial Symposium on Guided Missile Electronic Test Equipment, Redstone Arsenal, Huntsville, Ala.

March 3-6
23rd Annual Meeting of the American Society of Photogrammetry, Shoreham Hotel, Washington, D.C. For information write J. W. Halbrook, Chairman, 204 Lafayette Drive, Alexandria, Va.

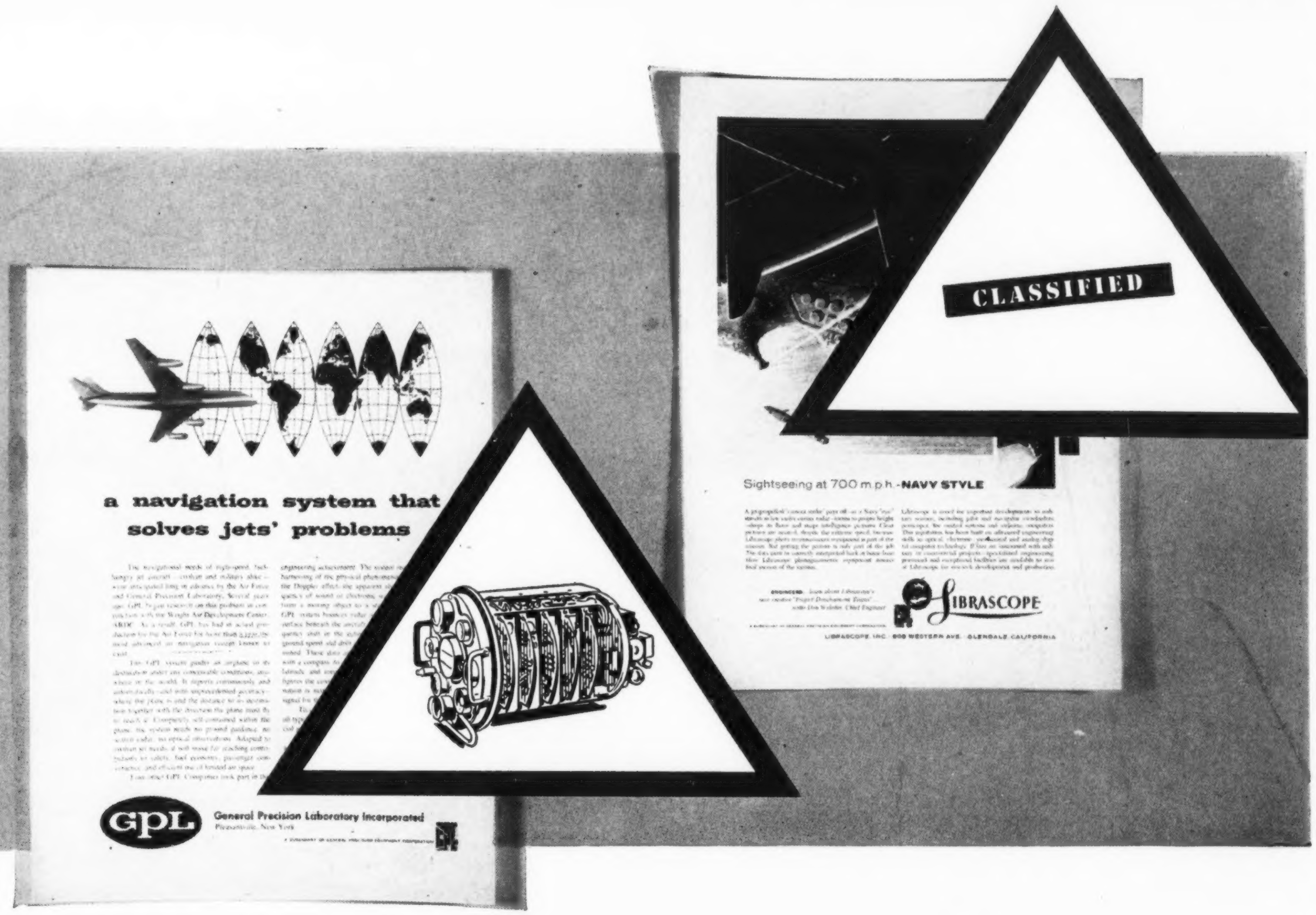
March 5-8, 1957
4th Annual Conference on High Speed Computers, Louisiana State University, Baton Rouge, La.

March 6-9
17th Annual Meeting of the American Congress on Surveying & Mapping, Shoreham Hotel, Washington, D. C. For information write Franklin G. Williams, Chairman, 5514 Nevada Ave., N. W., Washington, D. C.

March 11-14
The IRE Professional Group on Nuclear Science is cooperating with the EJC Second Annual Nuclear Science and Engineering Congress in Philadelphia. For information write Dr. Sidney Krasik, Editor, IRE—PGNS Transactions, 5621 Wilkins Ave., Pittsburgh 17, Pa.

March 11-15
Nuclear Congress, Convention Hall, Philadelphia, Pa. For information write Engineers Joint Council, 29 West 39th St., New York 18. N. Y.

March 14-16
National Military-Industrial Conference, Conrad Hilton Hotel. For information write Armour Research Foundation of Ill. Inst. of Technology, 10 W. 35th St., Chicago 16, Ill.



BENCH MARKS

18 pounds. Yet it provides accurate heading information at all latitudes, is rugged enough to maintain its high accuracy despite the jolts and speeds of jet flight. The Air Force has just selected it as standard for all new fighter craft. Kearfott's N-1 Compass System has been the navigational standard for Air Force bombers for 5 years.

Still another member of the GPE Group, General Precision Laboratory, has developed and is currently making quantity deliveries of the most advanced airborne navigation systems in use. These GPL systems, which are self-contained and fully automatic, have flown millions of operational miles with unprecedented accuracy. Their adaptations to civilian jet needs—GPL's RADAN Systems—are expected to make equally far reaching contributions to the commercial jet transport field—in the way of increased safety, fuel economy, passenger convenience and efficient use of limited air space.

These are but some of the accomplishments in aviation for which GPE Companies, working in conjunction with the Armed Services, are responsible. Librascope, an important member of the Group, produces outstanding instruments and equipment for the field. Librascope's computers, its highly advanced equipment for photo-reconnaissance work and photogrammetric equipment for the interpretation of photo data, its periscopes, pilot and navigator finders, are all leaders. Several GPE Companies are deeply involved in inertial guidance, guided missile projects and certain nuclear power applications.

In all GPE achievements in the numerous industries in which the companies work, GPE Coordinated Precision Technology plays an important part by inter-relating the wide range of skills and resources of the Group. This operating policy, and each company's unremitting insistence on highest quality, are major reasons for the frequency with which GPE systems and equipment continue to set standards in their fields.

EQUIPMENT CORPORATION

THE GPE GROUP *Askania Regulator Company • Bizzelle Cinema Supply Corporation • Bludworth Marine • General Precision Laboratory Incorporated Graflex, Inc. • The Griscom-Russell Company • The Hertner Electric Company • International Projector Corporation • Kearfott Company, Inc. Kearfott Manufacturing Corporation • Librascope, Incorporated • Link Aviation, Inc. • J. E. McAuley Mfg. Co. • National Theatre Supply Company Pleasantville Instrument Corporation • Precision Technology, Inc. • SEC-o-matic Corporation • Shand and Jurs Co. Society for Visual Education, Inc. • The Strong Electric Corporation • Theatre Equipment Contracts Corporation*

For more information circle **15** on inquiry card.

March 18-21
Second National Conference of Gas Turbine Power Div., American Society of Mechanical Engineers, Sheraton Cadillac Hotel, Detroit, Mich.

March 18-21
Institute of Radio Engineers National Convention and Radio Engineering Show, Waldorf-Astoria Hotel and the New York Coliseum. For more information write IRE, 1 E. 79th St., N. Y. 21, N. Y.

March 25-28
Physical Society Exhibition of Scientific Instruments and Apparatus, New and Old Halls of the Royal Horticultural Society in Westminster, London. For information write J. E. Reeve, Commercial Dept., British Embassy, Washington, D. C.

April 10-12
First National Nuclear Instrumentation Conference, Hotel Biltmore, Atlanta, Georgia, sponsored by ISA. For information write Herbert S. Kindler, Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

April 11-13
Ninth Southwestern IRE Conference and Electronics Show and the Second National Simulation Conference, Shamrock-Hilton Hotel, Houston, Texas.

April 14-16
National Symposium on Telemetering and Exhibits, Sheraton Hotel, Philadelphia, Pa. For information write Fred Fanella, General Electric Co., Special Defense Projects Dept., 3198 Chestnut St., Phila. 4, Pa.

April 15-17
A Symposium on Systems for Information Retrieval will include demonstrations of working equipment and be held at Masonic Auditorium, 3615 Euclid Ave., Cleveland 15, Ohio. For more information, write Jesse H. Shera, Dean, School of Library Science, Western Reserve University, 11161 E. Blvd., Cleveland 6, Ohio.

April 26-27
11th Annual Spring Technical Conference on Television at Engineering Society of Cincinnati Bldg., Cincinnati, Ohio. For information write Charles B. Shaw, Jr., Hangar 3, Lunken Airport, Cincinnati 26, Ohio.

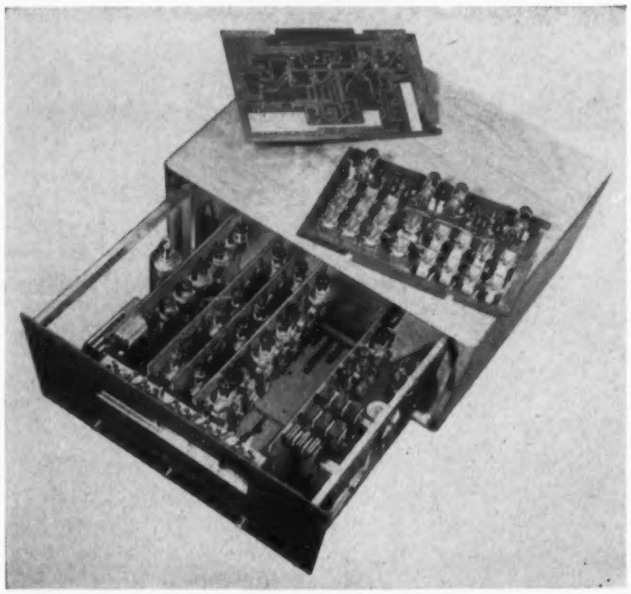


Fig. 1-1. Digital voltmeter using 8 vertical and 1 horizontal printed boards. (Photo courtesy Linear Systems and Formica Co.)

Printed Circuitry

Printed wiring and printed circuits are changing the basic character of modern electronic circuits. This discussion of terminology, advantages and basic factors introduces a complete series on this important subject.

ALLAN LYTEL

General Electric Company

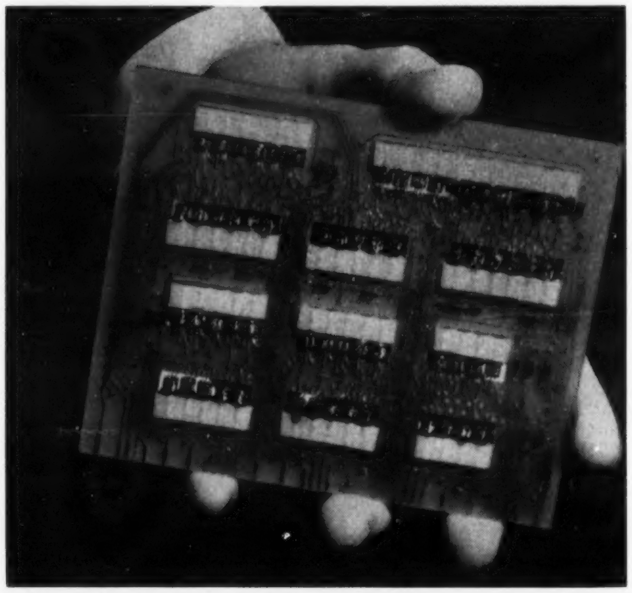


Fig. 1-2. Printed-circuit board with transistors from a digital computer. (Photo courtesy Philco Corp.)

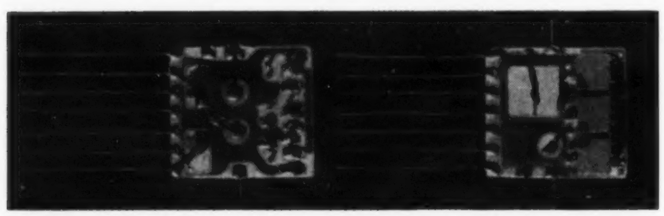


Fig. 1-3. Printed-circuit package. (Photo courtesy Centralab, Inc.)

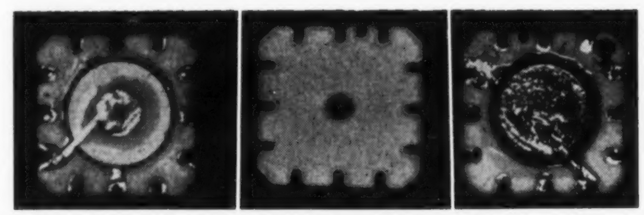


Fig. 1-4. Tinkertoy modular wafers. (Photo courtesy the National Bureau of Standards)

The Author

ALLAN LYTEL has attended Haverford College, Pennsylvania State College, and Temple University, from which he holds a B.S. degree in mathematics.

During World War II he served as radar instructor in several Army Air Force and Signal Corps schools.

After the war, Mr. Lytel was in charge of the Mobile Communications System for the "Big Inch" and "Little Inch" pipelines. The last five years he has been a lecturer in electronics at the Technical Institute and Community College of Temple University, where he has taught courses in ultrahigh frequency, a-m and f-m receivers and transmitters, tests and measurements, and physics. During this time Mr. Lytel has written several textbooks. He is currently with the Technical Information Unit, Electronics Lab., General Electric Co., Electronics Pk., Syracuse, N. Y.

DISCUSSION of the techniques known as "printed circuits" or "printed wiring" properly begins with a definition of these terms. *Printed wiring* refers to the use of solid metallic conductors made in reproducible patterns and bonded to an insulating base material. *Printed circuits* use printed wiring plus components such as inductors, capacitors, or resistors made by similar techniques.

The two terms—"printed circuits" and "printed wiring"—are used interchangeably and not always in their purest sense. The word "printing" is not always accurate. Some processes do not use printing techniques, but are still referred to as "printed" because the final product is like that of the printing process.

The first printed circuits resulted from a search for a technique which could be mechanized for large-scale

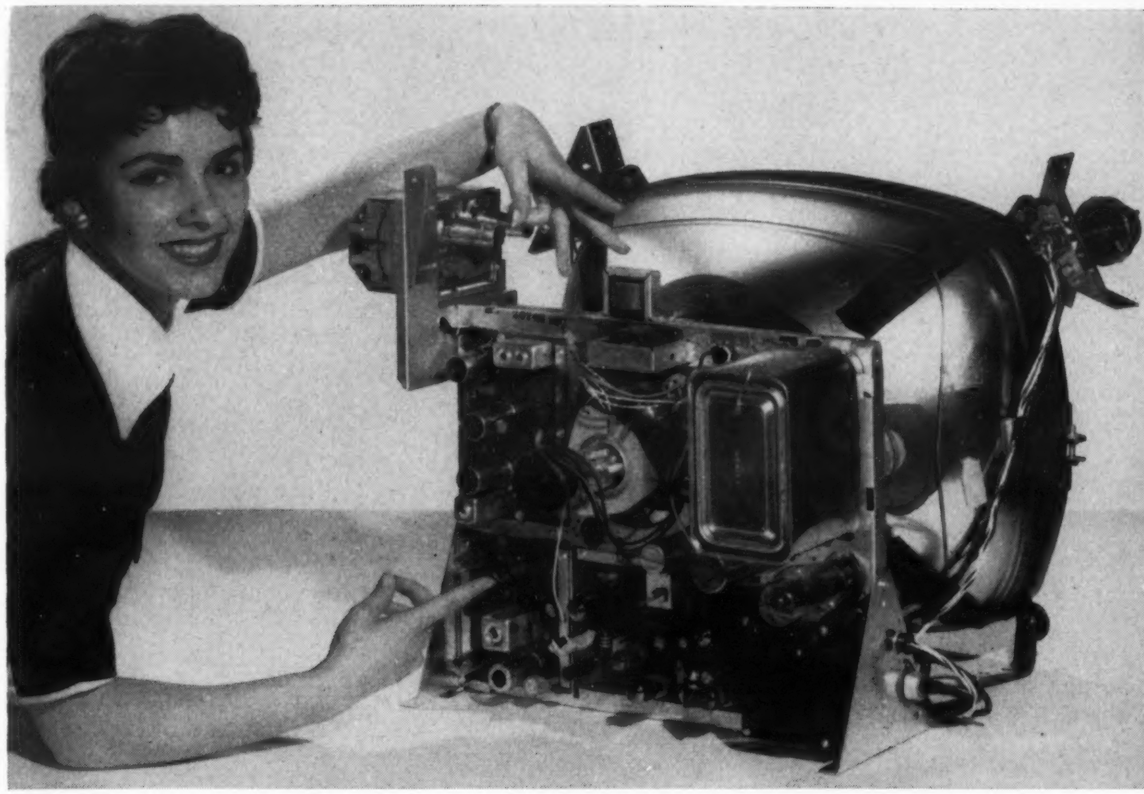


Fig. 1-5. Television receiver with three printed-circuit boards which contain 75% of the circuitry—231 components and 13 tubes. (Photo courtesy Admiral Corp.

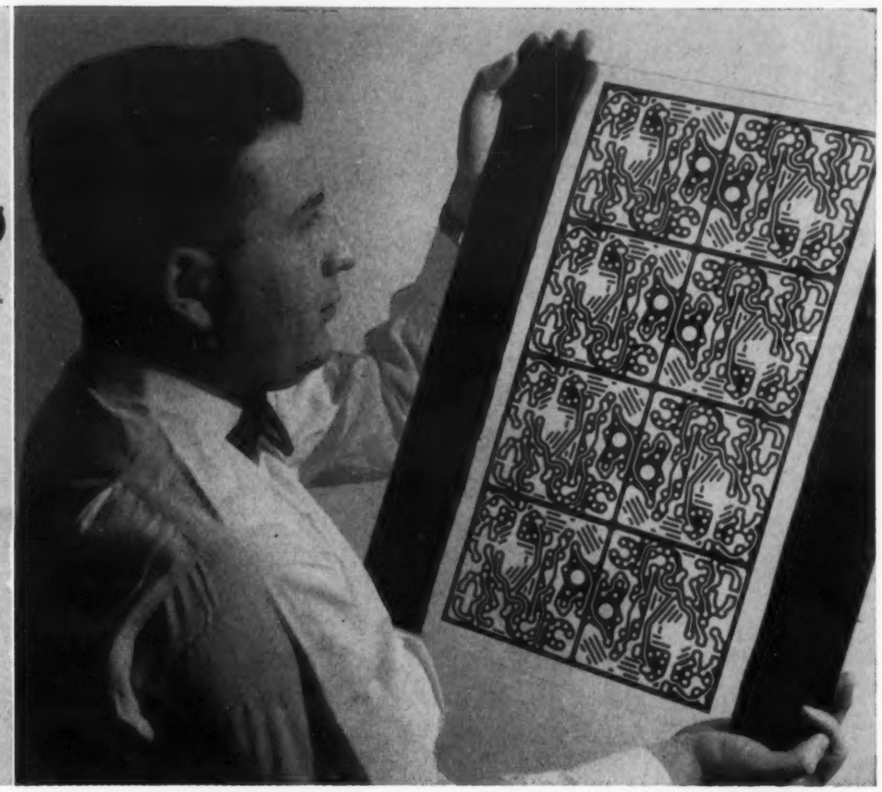


Fig. 1-6. Printed-circuit master drawing reproduced for production.

production. Credit for early U. S. development belongs to the National Bureau of Standards. This search for a method to bring electronics production up to the efficiency standards of other industries was begun during World War II. Experimentation began with silver paint applied through a stencil and fused with heat to form a metallic circuit. Because ordinary base materials could not withstand the 1000°F fusion temperature, ceramic materials such as steatite were introduced.

Three developmental paths were followed based on the steatite-based circuits with printed silver conductors, resistive paints, and printed components:

A. *Printed-Circuit Packages.* Commercial development led to small units, such as shown in Fig. 1-3, which were included in larger circuits. These packages each contain several components and are assembled into commonly-used circuit designs.

B. *Tinkertoy Modules.* The National Bureau of Standards developed a basic standardized wafer. As shown in Fig. 1-4, each wafer contains a component, or group of components. By proper inter-connection (stacking) it is possible to make complex circuits. This basic concept is now commercially produced* in small lots for developmental circuit work while improvement continues.

C. *Other Printed-Circuit Techniques.* These early developments caused still a third direction of effort. The basic printed circuit has developed into many newer techniques, such as using copper foil bonded to a plastic base. Excess copper is removed so that the remaining copper forms the desired circuit.

Uses of Printed Wiring

A wide range of electronic equipment is now being produced with printed wiring—hearing aids, digital computers, television receivers, aircraft antennas, test equipment, automobile dash-boards, etc. Because printed wiring is so well adapted to mechanization and eventual full automation, it has an important place in the future of the electronics industry.

Fig. 1-1 shows a digital voltmeter with one horizontal and eight vertical boards used as "packages." Each board contains wiring and components for a complete circuit. Placement of individual boards makes servicing or replacement of parts simple.

In Fig. 1-5 three printed boards contain 75% of the television receiver circuitry. The three boards contain 231 components, including 13 tubes. Some receivers have used printed wires in the tuner for several years.

Transistors supplement printed wiring; combined they make for effective miniaturization. As transistors require only small amounts of power, there is no heat-dissipation problem and their printed-wire circuits may be even more compact. An example of this combination is shown in Fig. 1-2; this printed-wire board, with transistors and resistors, is a circuit package from a digital computer.

Making the Printed-Wire Board

Printed wires represent a totally new and different approach to electronics assembly and design. The special features and design problems must be engineered as a part of the original circuit design.

As the circuits are mass-produced, production changes are difficult to make. Thus an engineering study of the circuits is made before they are produced as printed circuits. Changes in the course of production require that the technicians who will be responsible for repairs be informed of the changes.

In the basic subtractive process a copper-clad board is printed with acid-resistant material wherever conductors are to remain in the final circuit. Etching removes the excess copper and the result is the desired array of conductive "wires." Holes punched in the board allow mounting of components; usually by means of their lead wires. After these are mounted the board is completed by soldering; usually by dipping in a solder bath.

There are several ways to impress the acid-resistant pattern on the copper surface. It may be *printed* (offset method), *photoengraved*, or *silk-screened*. Another technique uses a hot die which die-stamps only the desired conductors into the surface of the insulating base material. All systems will be described in detail in the following discussions.

The manufacturing process for the offset printing and etching method is quite different from normal wiring. The first step is a layout drawing from which a master is made. Fig. 1-6 shows a master containing six identical circuits. The acid-resistant film (acid resist) is printed with a press, as shown in Fig. 1-7. A metal plate transfers the impression to a rubber blanket which offsets the printing onto the copper-coated board.

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* ACF Industries, Aerovox, and others.

Fig. 1-7. Production of printed circuits. (Photo courtesy Croname, Inc.)

Fig. 1-9. Stamping printed boards. (Photo courtesy Methode Mfg. Corp.)

Fig. 1-8. Punch-press cutting of printed boards. (Photo courtesy General Electric Co.)

After an etching bath has removed all copper unprotected by the "etch-resist" the boards are stamped, either in a group (Fig. 1-8) or individually (Fig. 1-9).

The holes in the printed lines are drilled or punched out for mounting components. Standard resistors, capacitors, or even i-f transformers may be mounted to the board by machine. After the leads are cut and crimped the entire unit is dipped into a solder bath, soldering all connections at the same time. The circuit is now ready to be mounted in the television or radio chassis.

Sometimes it is possible to fabricate certain components by the same methods. A spiral of copper foil can serve as an inductance; a printed line of carbon ink can act as a resistor; copper pads on each side of the board can act as a capacitor with the base acting as the dielectric.

The finished product can be a simple single board (Fig. 1-11) or a complete chassis on a single board (Fig. 1-10). In Fig. 1-11 the master drawing of a circuit is shown in part A. The wiring side of a small board is shown in part B (note numbering for the leads, tube socket pins, and component lead locations), and the component side (of B) is part C. A board which serves as the entire chassis is shown in Fig. 1-10. This is a small table radio with all components mounted on the single board, which mounts vertically in the cabinet.

Advantages of Printed Wiring

Printed wiring can be accomplished by automatic machinery more easily than can the older point-to-point wiring.

Printed wiring has a high degree of uniformity because mechanical reproduction assures standard treatment. Thus, individual wiring errors are eliminated and the quality of the circuit and its construction is not only high, it is uniformly high.

Equipment design is simplified, and circuit designs not possible before are now feasible. For example, microwave antenna arrays, which are difficult to manufacture with the required tolerances, can be printed accurately at reduced cost. Less weight means that final equipment is lighter; this is very significant in airborne electronics.

Some circuits, such as audio and video amplifiers, have been used repeatedly as building blocks. They are sometimes called *modular circuits*. From a group of

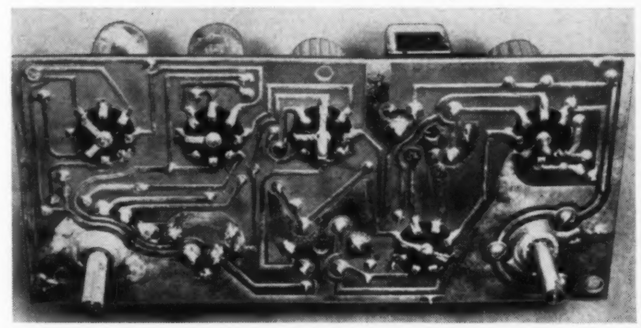
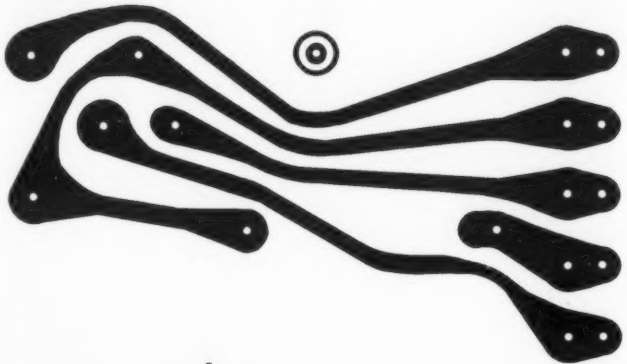


Fig. 1-10. Table-model radio showing wiring side. (Photo courtesy Methode Mfg. Corp.)

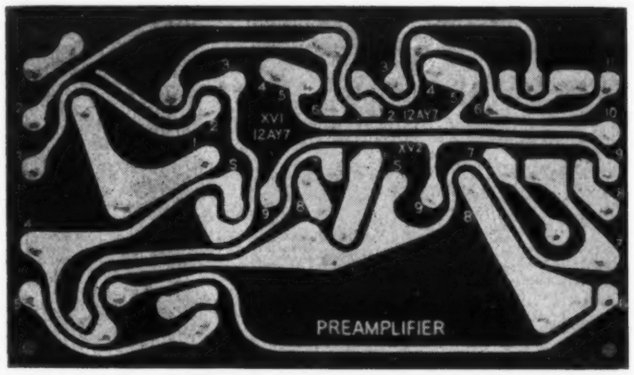
modular circuits many equipments may be assembled. Engineering effort can be redirected toward making the best possible modular circuits. Greater use of a few circuits means production economies that lower cost of the final product.

Lead dress is often a problem with critical circuits. The capacity between leads or between leads and chassis is often a source of trouble with some signal circuits. This problem is overcome with printed circuits wherein wires are always in the same position in relation to each other. Once the wires are laid out, capacity can be measured and proper compensation made.

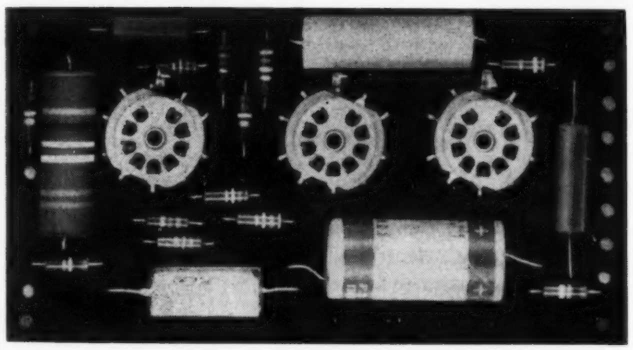
Components are always found in the same place on the board, which is an aid to troubleshooting. It is now a simple matter to locate and identify each component from its position on the board. The layout sheet, supplied as part of the schematic drawing, shows each part and its location.



A



B



C

Fig. 1-11. A. Master drawing for a simple printed-wiring pattern. B. Etched wiring in an audio amplifier. C. Component side of same etched-wiring board shown in B.

A great advantage of printed circuits is that it is possible for the technician to replace circuits for troubleshooting. For example, if trouble is traced to the video i-f amplifier, the entire unit can be replaced. Replacement is not used for *all* troubleshooting, but where there is a stubborn fault, replacement has great value.

Following discussions will include:

- Design problems of printed circuits
- Development of printed circuits
- Components for printed circuits
- Receivers and audio amplifiers
- Radio-frequency applications
- Computer applications
- Servicing the printed circuit
- Mechanized manufacture of printed circuits

To be continued in the next issue

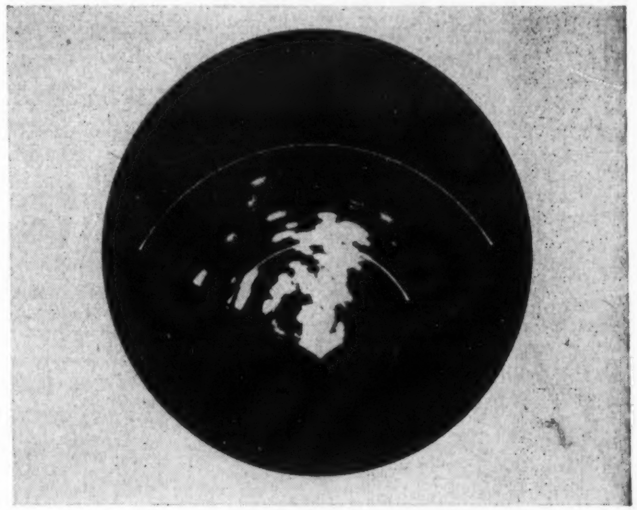
Improved Radar Target Definition

DESIGNED specifically to complement airborne radar equipment, the **Clutter-Operated Anti-Clutter (COAC)** Receiver uses impulses returned from a "cluttered" target to automatically adjust the radar set to each element of the target. These target elements are now shown as well-defined individual images. Without the new device, radar equipment favors the largest target on the screen, to the extent that small images, returning a lower level of reflected energy, tend to blend in with the fringe of the larger image, and can be completely obliterated by the stronger target (Fig. 1-A). The new unit preserves high incremental gain for signals of narrow dynamic range and compresses stronger signals, and signals having a large dynamic range, by as much as 80 db (Fig. 1-B).

The COAC Receiver in airborne radar equipment will provide clearer landmarks for navigation, give more faithful information for avoidance of air collision, and show storm fronts in the path of aircraft.

COAC has same physical specifications as standard amplifiers and can be substituted for the original amplifier with a few changes in wiring. The COAC amplifier makes gain control unnecessary, except when it is desirable to focus on one individual image to the exclusion of definition of others within a target area. Usually the radar technician need adjust only the antenna tilt and brightness controls of the equipment.

With minor modifications, the COAC Receiver can be adapted to meteorological, land, or ship radar sets. The COAC system is designed by Allen B. DuMont Laboratories, Inc.

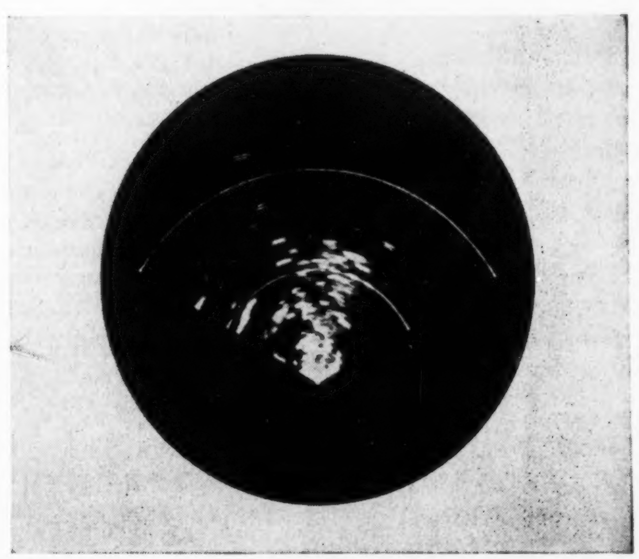


A

Fig. 1. "A" shows image of a typical New Jersey metropolitan landscape on a radar set not equipped with the COAC unit. Bridges, buildings, water towers, and other promontories tend to blend together as one basic image with several poorly defined smaller spots. "B" shows the same view on a COAC-equipped unit with each element shown individually on the screen. The more specific information gives navigators better landmark guides and tells them in greater detail the nature and number of obstacles which may be in the flight path. The COAC unit automatically adjusts to images returning a smaller degree of reflected energy while still retaining the individual outline of larger images.

Photos courtesy of Allen B. Du Mont Laboratories, Inc.

B



2-5000 PPS (Pix/Sec)

THIS lightweight airborne 16-mm high-speed camera, capable of 2000 pictures per second, will withstand 100 g's shock and operate at 50 g's constant acceleration. Another model has been designed for 5000 pps. Called the "Motion Analysis Camera" (MAC), it uses rotating prisms, and can be adapted to many uses. Industrial and airborne models have film capacities of 100 and 200 feet, using daylight loading spools (Fig. 1).

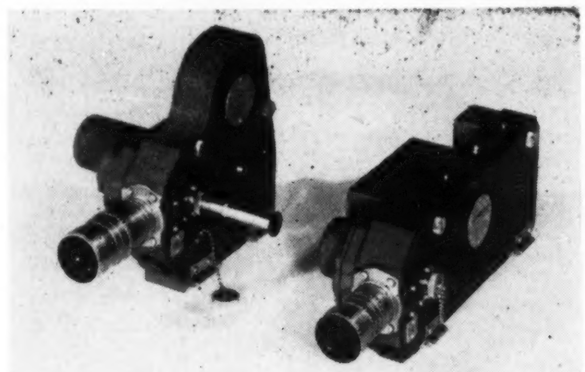


Fig. 1. Two Motion Analysis Cameras; one designed for general industrial use is left, the other is for airborne use.

Resolution tests of the MAC produce results equal to or better than those obtained with intermittent cameras operating at 64 pictures per second and more. *Picture steadiness* on projection is much better from 100 to 1,000 pps than that of the intermittent cameras.

The rotating prism is selected for the highest possible index of refraction and lowest dispersion with a minimum thickness and minimum angle of incidence. The result is an evenly illuminated picture that has a sharp frame line, with no overlapping of images of one frame into the next.

Since the introduction of high-speed color film, glasses of higher indices of refraction cannot be used for prisms because they have color, generally yellow. Therefore, a rare-element glass is used for the 4-sided prism, which is as nearly "water-white" as possible, with a high index of refraction and low dispersion. Thus the image is free from "color fringing," and color photography is possible without color correction filters.

The camera is simple to operate and load. There is only one switch on the camera, and two sockets; one for motor power and one for the timing light. At picture-taking rates up to 1000 per second, an adjustable brake can be set to prevent overrun of the feed spool when the camera is stopped and started for several runs on a single roll of film. In

addition, speed can be varied while film is passing through the camera.

During recent tests the camera exceeded the limits of laboratory testing by an appreciable amount. In the first of two studies an MAC was mounted on the floor of a rocket propelled sled. Deceleration forces were in excess of 60 g's when the sled shot by at 600 mph. Vibration of the sled floor far exceeded laboratory test conditions. Timed to study the ejection of a pilot's seat, the camera ran at 800 pps—clearly recorded the functioning of ejection.

At the same time a similar camera, mounted near the track opposite the point of seat ejection, used color film and a half-inch focal length (wide angle) lens to take ejection (Fig. 2).

Subsequently a second study was made on a sled travelling at supersonic speeds. An MAC, riding on the floor of the sled, operated successfully during an initial acceleration of 200 g's, which finally settled down to 50 g's. Color film again showed fine results.

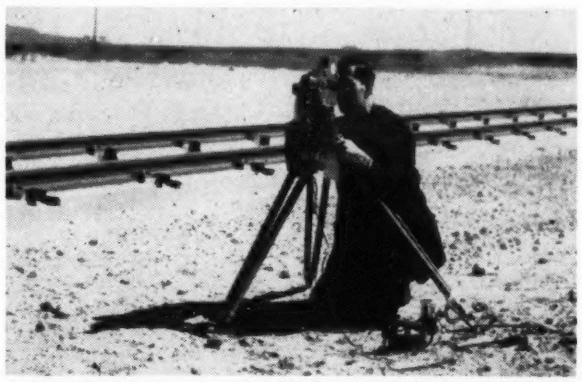


Fig. 2. At the site of a high-speed sled track, John H. Waddell, designer of the new Motion Analysis Camera, prepares to "slow down" a rocket sled with 2000 pictures per second.

From MAC Specs—
HS 100: AERIAL MODEL:
100-foot 16-mm high-speed motion picture camera suitable for airborne and rugged use, furnished with 28-volt d-c motor will permit from 100 to 1,000 pictures per second to be taken. Suitable for use with other motors in a series listed below.
Weight: 11 pounds.
Dimensions: 11⅞" long, 4¾" high and 4⅜" thick. Equipped with f/1.5, 13-mm lens with bayonet lock. Three mounting holes provided for ⅜" x 16 thread screws and one ¼" x 20 mounting hole. Detachable door. Open-sight view finder, which can be corrected for parallax, and various focal length lens fields from 13-mm to 152-mm.
HS 503:
Motor assembly suitable for taking pictures from 300 to 3,000 per second.
HS 504:
One pair of motors for taking pictures at rates from 500 to 5,000 pictures per second.

Photos courtesy Fairchild Camera and Instrument Corp.

Advanced Doppler Navigation

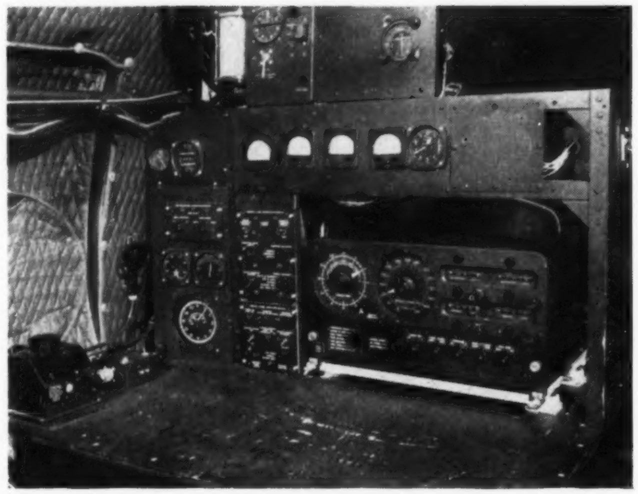


Fig. 1. Navigator's control panels of prototype Radar Navigation Set AN/APN-66 installed for the Air Force in a C-54 type aircraft. Some of the electronic gear shown is additional instrumentation for flight testing purposes.

Fig. 2. Course and position indicator displays data used in airborne navigation and continuously indicates present position of aircraft in latitude and longitude.

MILITARY AIRCRAFT are now using production models of Doppler Navigation Set AN/APN-66, said to be the most advanced air navigation system in operational use (Fig. 1). Using the Doppler effect, the AN/APN-66 directly measures ground speed and drift angle, the "heart" of air navigation. The system operates automatically anywhere in the world without any outside aids, such as ground-based stations or celestial fixes. The AN/APN-66 navigates in any weather, including zero visibility, and over all types of terrain. Designed and developed for the most modern aircraft by General Precision Laboratory, Inc., the system accommodates extremely high speeds and altitudes.

Significance

The AN/APN-66 system achieves a significant technological break-through since delay in computation using optical or radar fixes often makes information obsolete because of the high speeds of modern aircraft. Furthermore, optical ground fixes are impossible in bad weather and very limited at night, and search-radar fixes are not available over open water. Celestial navigation is difficult, slow, subject to large human errors, and cannot be used when flying through an overcast sky. APN-66's advance over all classes of navigation systems in operational use that employ ground-based aids (such as VOR-DME, TACAN, LORAN, etc.), is apparent in their lack of world-wide coverage and war-time limitation due to their possible aid to enemy aircraft.

Basic Principle

The AN/APN-66 operates on the following basic principle. If an aircraft *in motion* transmits electromagnetic pulses to the ground, the return pulses will be slightly shifted in frequency due to Doppler effect. From Doppler shift of pulses, the aircraft ground speed and drift angle (due to winds) are determined. This information is continuously combined with compass heading to provide an instantaneous indication of aircraft position.

Operation

After the pilot flips one switch at the start of flight, the aircraft can be flown automatically along the shortest route to any desired destination. The aircraft's present position is shown on latitude and longitude counters every moment of the flight (Fig. 2). The AN/APN-66 also displays all other information needed for air navigation, such as ground speed, drift angle, wind speed and direction, shortest course to destination, steering signal, etc. System accuracy is the best ever achieved by a global navigator. For instance, at the calculated end of a flight of several thousand miles, the pilot can look at the earth below and see his destination.

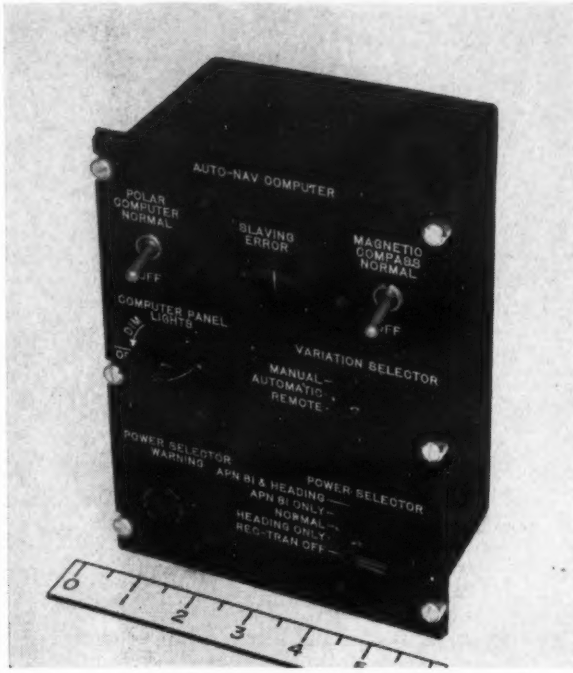


Fig. 3. Auto-Nav computer control panel contains switching controls for special operation in polar regions where there is rapid fluctuation of magnetic variation.

The U. S. Air Force has flown the AN/APN-66 to all parts of the United States, over the North Pole, to England, Spain, Turkey, and Japan. The equipment operates successfully over all types of terrain and open seas—is particularly useful in polar flights where rapid changes in magnetic variation make fast, accurate navigation unusually difficult. When close proximity to the magnetic pole makes it impossible to use it for a reference point as in normal navigation, the AN/APN-66 automatically switches to "transverse operation". This means the set makes its calculations based on a new "pole" established on the equator near the 180° meridian. Present position continues to be supplied without delay as all calculations involved are performed automatically and instantaneously by the equipment. This ability may permit reduction of the normal complement for polar flying from three navigators to one.

Memory

Memory enables the AN/APN-66 to compute and indicate accurate data even if Doppler pulse contact with the ground is interrupted, or if the pulsing system is temporarily shut off. Additional features are: (1) Any revision in flight plans is readily handled by automatic computation of the desired course to destination. (2) Exceptional system reliability—proven by flight records. (3) Equipment malfunctions can be located without opening any "black boxes." Rapid maintenance is achieved by electronic plug-in assemblies that are interchangeable. (4) Only the operator's controls and indicators need be installed in the crew compartment. Other units of the system may be installed in remote locations in the aircraft.

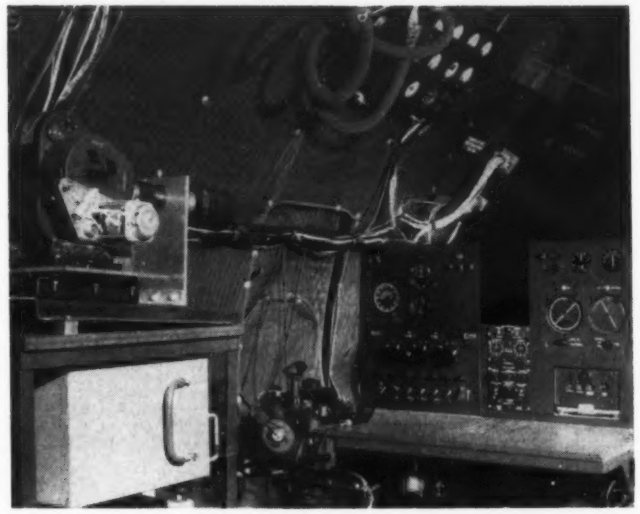


Fig. 4. Special installation at navigator's position made in a B-29 type aircraft showing controls and instrumentation for Radar Navigation Set AN/APN-82. Provision has been made to record the navigational data photographically.

Applications

The AN/APN-66 is applicable to global navigation, bombing, aircraft carrier operations, aircraft early warning, map making, magnetic surveys, jet stream research, missile guidance, weather reconnaissance, air-sea rescue, in-flight refueling, and strip-film synchronization for aerial photography.

Equipments

The AN/APN-66 system consists of two equipments: (1) Radar Set AN/APN-81, the Doppler portion, provides continuous measurements of ground speed and drift angle. (2) Navigational Computer Group AN/APA-95 accepts these quantities plus heading information as inputs and performs all the navigation and computation functions indicated on control box (Fig. 3).

The AN/APN-81, with its highly-accurate outputs, provides an excellent foundation for building navigation, reconnaissance, bombing and missile-guidance systems.

Weather Reconnaissance

For tactical and weather reconnaissance applications, the AN/APN-81 is interconnected with a ground-position computer to form Radar Navigation Set AN/APN-82 (Fig. 4), a smaller, lighter system providing slightly-less-complete navigational data than the AN/APN-66. Quantities of these smaller systems are being installed in RB-66 reconnaissance aircraft, and Air Weather Service's WB-50 aircraft. Systems installed in B-29 and B-47 aircraft are being used daily to investigate the jet streams (high speed winds at higher altitudes which enable aircraft to fly with maximum tail winds or minimum head winds). The "wind computer" portion of the AN/APN-81 enables these aircraft to minimize flight time, such as one B-29 which traveled from Texas to Florida in less time than a much faster bomber which did not have a Doppler wind computer. The positions, speeds, and directions of recent hurricanes have been accurately determined by AN/APN-82-equipped planes.

Photos courtesy of General Precision Laboratory Inc.

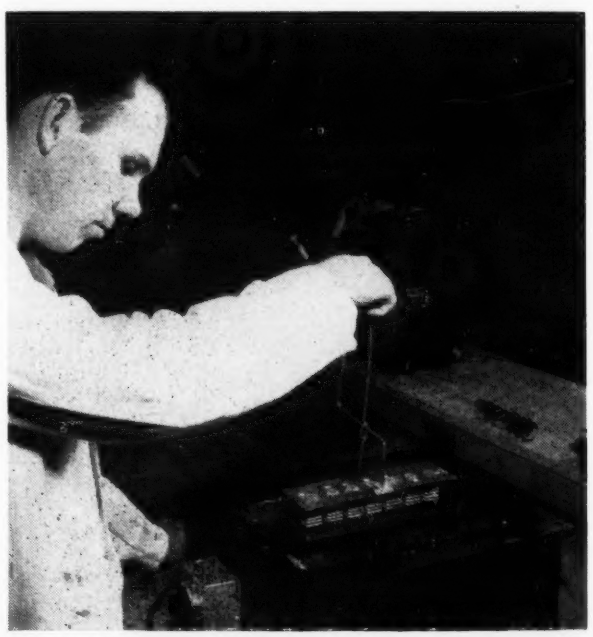
Aeronautical Electronic and Electrical Laboratory (AEEL)

Illustrations are Official Photographs U. S. Navy.

When a Lockheed WV-2 keeps her lonely vigil off the shores of the continental United States, or ranges far ahead of the fleet, she is an electronic, multi-eyed sentinel that gives to our defenses those few precious hours warning of imminent enemy attack. Credit for her protracted "vision" goes to the scientists and engineers of the Aeronautical Electronic and Electrical Laboratory, Naval Air Development Center, Johnsville, Pa.

The AEEL was established as a component of the NADC in 1947. Its physical growth started immediately, for it absorbed the Aeronautical Radio and Radar Lab, Naval Air Magnetic Lab, the Aviation Electrical Test Group of the Naval Research Lab, and the Naval Research Field Station at Boston, Mass.

The primary mission of the AEEL is to assist BuAer and industry in providing naval aircraft with modern electronic and electrical equipment. The laboratory is a necessity for the continued preliminary study, investigation and engineering of electronics. So fast has been the development, so broad the scope of this relatively new science that it would be impossible to dictate production



"Dip soldering" a set of modules. These modules, similar to the "tinker-toy" concept, are designed for fabrication by machinery instead of by hand. (See chapter one of "Printed Circuitry" series in this issue.)

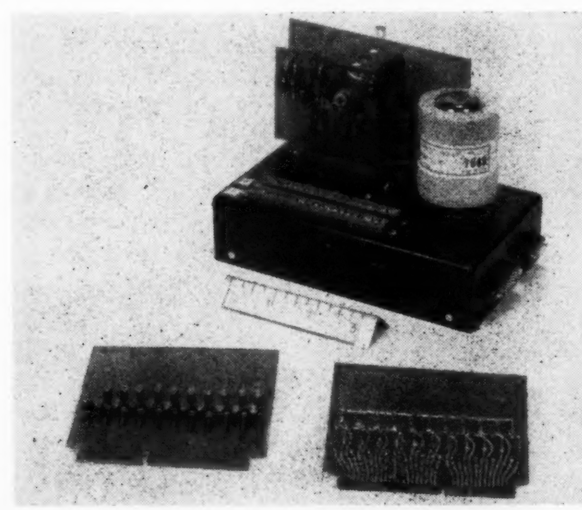
Modular design laboratory reduces size and weight of airborne electronic equipment developed in other divisions of AEEL. Work includes engineering for use of automatic production machinery in fabrication.

requirements to industry without first determining what surprising new capability can be proved feasible. The seemingly endless applications of electronics makes it mandatory that the AEEL be staffed by scientists who are not afraid to dream a little, and engineers who make those dreams come true. Men of vision, electronic "vision", literally.

AEEL has done pioneer work in (1) miniaturization of aircraft electronic and electrical systems, (2) modular design, (3) printed circuitry, (4) 400-cycle airborne electrical systems and (5) Piezoelectric ceramics, including the barium titanate transducers for sonar detection devices.

The lab is under the direction of Capt. Alden C. Packard (see biography on facing page). Interest is divided between equipment for use under, on, and above the sea.

Six divisions of the laboratory are Radar Division, Radio Division, Undersea Warfare Division, Control and Guidance Division, Electrical Division and Development Support Division.



A piece of electronic equipment after being re-designed by the modular design lab. Each of the 4 plug-in boards can be made by automatic machinery.

Bio-Bits

The purpose of these short biographical sketches is to provide our readers with an insight into the lives of some of the military and scientific leaders now guiding the development of automation in the different branches of the U. S. Armed Forces.

The editor has known and admired Captain A. C. Packard, USN, since first making his acquaintance in the South Pacific areas in 1943, when the captain was visiting that area as Commanding Officer of the Airborne Coordinating Group. The scope of his present responsibilities is suggested by the description and mission of the Aeronautical Electronic and Electrical Laboratory, U. S. Naval Air Development Center, Johnsville, Pa., which also appears in this issue.

Capt. Alden C. Packard USN

Captain Alden C. Packard was born in Los Angeles in March 1906. He exhibited an early interest in wireless communication, earning his first "Ham" radio license (W6RL) at the age of fifteen. His first transmitter consisted of a Ford spark coil followed by a half-kilowatt spark with rotary gap. This was replaced by a UV 202 in 1922 for his first vacuum-tube transmitter.

The Packard family moved to Claremont, California in 1912. Alden graduated from Claremont High School in 1923 and entered Pomona College, from which he graduated in 1927 with his BA and a commission as Second Lieutenant, Infantry Reserve, U. S. Army. Deciding on a career in radio engineering, he entered Harvard University Engineering School as a graduate student, and graduated in June 1929 with a Master of Science degree in Communications Engineering. Graduation was accompanied by wedding bells as he married Miss Florence Eye, from his home town of Claremont, California.

In his first job following graduation, he was engineer-in-charge of construction of a high-frequency ship-to-shore and point-to-point radio telegraph station, KYG-KGS at Kaena Point, Oahu, T. H. Contractor was Heintz & Kaufman, LTD., of San Francisco. This station is still being operated by Globe Wireless, Ltd.

He transferred from the U. S. Army Reserve to the U. S. Naval Reserve as LTJG USNR in 1932. Following completion of the Kaena Point Station, Al was employed, from 1932 to 1935, as radio engineer in the Los Angeles broadcast stations KMTR and KFAC. His first son, Alden H., was born in 1932, soon after his return to the states. The Packard's second son, John T., was born in 1933.

In 1935, Al joined KNX/CBS as radio engineer, becoming Supervisor of Maintenance, CBS—Los Angeles, in 1936. He held this position until May 1941.

As a result of the Navy's participation in the North Atlantic Patrol, Al was ordered to active duty as Lieutenant, USNR, in May, 1941. After a brief period in Airborne Radar with the RAF in Canada, he was ordered as Radar Officer on the staff of RADM Mullinix, USN, Commander, Patrol Wings, Support Force Atlantic Fleet, based on the USS ALBEMARLE in the North Atlantic. The patrol planes flown by this Wing were the Navy's slow but reliable workhorses, the PBYs. The first two PBYs equipped with the British ASV radar to see service in the U. S. Navy were received by Lt. Packard on this duty. This radar and the American-built copies that came later were the only airborne radar equipments we had, and the PBY was the only Naval plane capable of carrying the two large YAGI antennas. These antennas were mounted under the wings on each side of the fuselage (the first two planes had Sterba curtain antennas mounted on the hulls).

Shortly after the Jap attack on Pearl Harbor, Lt. Packard was ordered to a series of short duty assignments at several Naval Air Stations. His first assignment was Assistant Radar Officer, NAS, Norfolk; next Radar Officer, NAS, Alameda, in February, 1942; then Radar Officer, NAS, Coco Solo, Canal Zone, in June, 1942. In these tours his mission was organizing a Radar Division, installing equipment and training maintenance technicians and operators. The last of these transfers was to the Naval Air Station, Quonset Point, R. I., in August, 1942. Here the Navy's first X-band airborne radars, the ASD, were installed in PV-2 aircraft for European service. This tour lasted nearly a year.

During this period airborne radar problems were building up in every theater and grounding too many planes. Much electronic equipment was being installed before development was completed. Because of the speed with which improved radars were being developed and produced, personnel seldom could be trained on the type of equipment they were to receive and maintain in the fleet. There were too few factory-trained engineers to supply all places where they were needed. Something had to be done to save the situation.

This "something" was accomplished by the Airborne Coordinating Group, Naval Research Laboratory, Washington, D. C., to which LCDR Packard was ordered as Commanding Officer in July, 1943. This organization of technically-trained officers and contract civilian engineers was available at a moment's notice for on-the-spot assistance in installation, trouble-shooting, maintenance or training anywhere in the world. Here was plenty of scope for Al's energy, ingenuity, training and leadership. The Airborne Coordinating Group did such an outstanding job that in 1946 CDR Packard was awarded the Legion of Merit for this duty.

In October, 1946, he transferred to the Regular Navy with the rank of Commander, USN. Post-war developments in avionics were multiplying, and in January, 1947, CDR Packard reported to the Electronics Division, Bureau of Aeronautics, as Head of the Guided-Missile Guidance Branch. During this tour he also served as Assistant Director for Design, later as Deputy Division Director, Electronics Division, Bureau of Aeronautics.

In August, 1950, he reported to the U. S. Naval Air Missile Test Center, Point Mugu, California, as Director of Test. During this period, for the first time in history, a drone aircraft was destroyed by a direct hit from a Lark missile. The first intercepts by an air-launched missile were also made. Another promotion came in January, 1951. In 1953 Captain Packard returned to the Bureau of Aeronautics, serving on the staff of the Assistant Chief of the Bureau for Research and Development. During the last year of this tour he was Executive Director, Research and Development, under RADM William A. Schroech.

In September, 1956, Captain Packard reported to his present duty as Director, Aeronautical Electronic and Electrical Laboratory, U. S. Naval Air Development Center, Johnsville, Pennsylvania.

Captain "Al" Packard still finds time to practice his hobbies of hunting, fishing and photography. His amateur radio call is now W3AA, and he holds a private airplane pilot's license, as befits a captain in the naval air arm. Son Alden H. is married and has just finished a hitch in the U. S. Army. Son John T., also married, is now finishing his flight training in the U. S. Air Force.

MA **Lit Bits**

Excerpts from important manufacturers' literature

Infrared Weapons Systems

An infrared detection system finds its target without producing energy to betray its own position. The hot exhausts of more powerful engines and higher skin temperatures from greater speeds are the factors which make even the smaller, modern aircraft vulnerable to detection by an infrared system.

Guided missiles, with their low total skin area cannot escape discovery by an infrared system. Infrared is concerned with total radiation . . . it is not solely dependent on the size of the target.

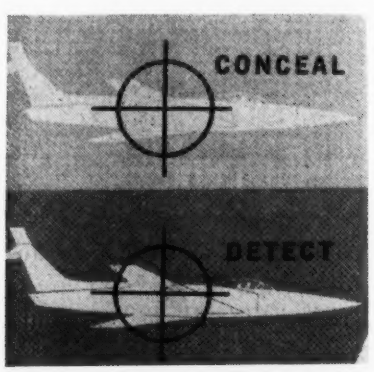
Countermeasures

. . . A complete radiation laboratory, suitable for mounting in bomber type aircraft, the AIM system detects intruding aircraft and supplies the following information under all flying conditions:

- gathers quantitative data on energy radiated from missiles and jet aircraft in flight
- analyzes the spectral distribution of energy of airborne targets
- determines spectral characteristics of airborne targets
- records this information in immediately visible stripchart form

Reconnaissance

Effective day and night, in clear or foul weather, high-speed infrared reconnaissance systems cannot be jammed by electronic countermeasures.



Nor can these systems be blinded by camouflage, for the infrared radiation generated by the enemy's own cities and industrial sites provide the means for their detection.

As an illustration of the sensitivity of these systems, the infrared detecting component, installed in a reconnaissance airplane, can register the amount of radiation that is emitted by a vehicle on the ground below.

Completely passive, there is no danger that the infrared reconnaissance system will reveal its position or source.

Guided Missiles

Guided by infrared detection during the terminal phase, a missile seeks out the target by literally feeling its warmth. Targets such as steel mills and factories in operation, moving trucks and cars, aircraft and other missiles in flight, and ships at sea are heat sources which transmit greater infrared radiation than the normal emissivity of the surrounding environment.

Bombing

These infrared systems . . . provide automatic, precise, tracking of a target. Once locked on its target—moving or stationary—the infrared system's computer directs bombing operations to pinpoint precision.

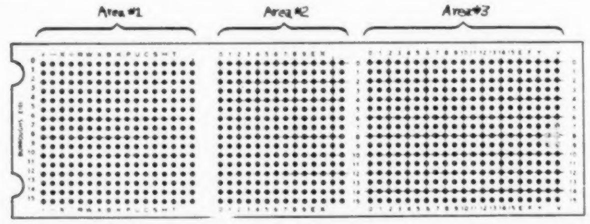
Fire Control

Because infrared radiation is transmitted by any medium—air, water, or solids—it forms the basis of a universal fire control system for aircraft armament, surface weapons, and ground artillery. The infrared fire control system does not rely on separate systems for information gathering. (*From new 8-page Bulletin IR-9902-56, Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, L.I., N.Y.*)

For this literature circle **101** on inquiry card.

E 101 Computer

The instruction symbols used for the E 101 program language are those with which everyone is familiar (+, −, ×, ÷, P for print, R for read from storage, etc.) There are no confusing code numbers or symbols to memorize. There is no language barrier between the people who have the problem and the E 101 computer method of solving it.



Step-by-Step "slide-rule" instructions make program for the E 101. A typical instruction consists of 1 pin in Area #1, and 2 pins designating memory location in Areas #2 & #3, in a single line.

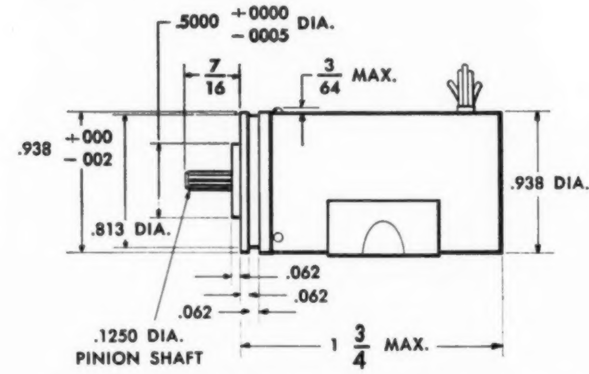
When you have written down the step-by-step instructions which you would give a desk calculator or slide-rule operator to solve a problem, you practically have the E 101 program for that problem. The instructions to the E 101 are expressed by the positions of removable pins placed in the novel pinboard units. A typical instruction consists of a pin for the operation to be performed, and two pins designating memory location.

Lowest in price of all general purpose electronic digital computers, the E 101 is designed to solve those problems that are too complex for efficient solution on desk calculators, and yet are too small for economical solution on giant "brains." What's more, it opens the door to answering problems whose answers are merely guessed at today. (*From new 8-page Bulletin EDP* 103, *Burroughs Corp., Computer Section,* 1616 *Walnut St., Phila.* 3, *Pa.*)

For this literature circle **102** on inquiry card.

Miniature Motor-Gearhead-Clutch

The high-performance 400-cycle servo unit operates directly from either a 115-volt or 26-volt line. The motor and the gearhead are enclosed in a common housing. This design minimizes alignment and assembly problems and results in a substantial reduction in size and weight. Servomechanisms' universal gearhead design makes a wide variety of gear ratios more readily available without changing the basic configuration.



The motor-gearhead can be supplied, at no increase in length, with an integral slip clutch to protect gearing and loads. The use of the slip clutch as a control element is especially important when one is confronted with the high stall torques resulting from the use of high gear ratios. The overall unit, which is 1¾″ maximum in length, is completely encased in an aluminum housing to give minimum weight and minimum temperature rise. It is designed to meet the requirements of MIL-E-5400. (*From new 2-page New Product Release, Servomechanisms, Inc., Mechatrol Div.,* 625 *Main St., Westbury, L.I., N.Y.*)

For this literature circle **103** on inquiry card.

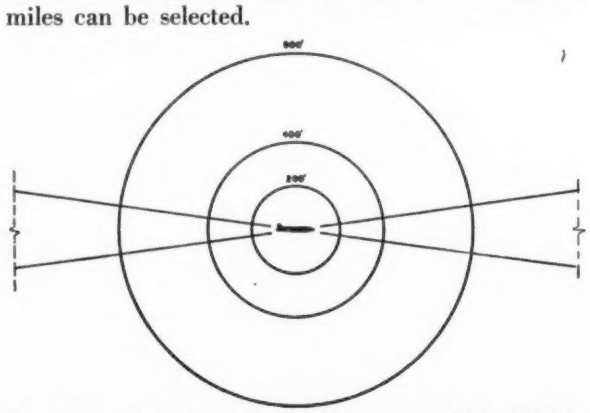
Automatic Collision Prevention

Development of electronic equipment to prevent aircraft midair collisions has been given a top priority by Collins following the Air Transport Association announcement Sept. 14 that Collins had the "most satisfactory" of several manufacturers' proposals.

The Collins plan proposed development of an interim equipment to warn the pilot of the presence of any aircraft dangerously close to his own. A more comprehensive equipment to follow this initial development will automatically determine if a nearby aircraft is on a collision path and advise the pilot of the evasive action to take.

Collins expects to have the detection device or "Proximity Indicator" available to the airlines in 1958, with the "Collision Detection and Avoidance" equipment ready the following year. The Phase II research is being conducted concurrently with Phase I development.

The proximity indicating equipment . . . will provide two functions. The first function is to detect and display aircraft that enter the flight plane (within an included vertical angle of 15 degrees) in any of the four quadrants: fore, aft, left or right of the aircraft. For this phase of the operation, maximum ranges of either 800 feet or two nautical miles can be selected.



Proximity detector warns if space within 800-ft sphere or in any 2-mile 15° quadrant is violated.

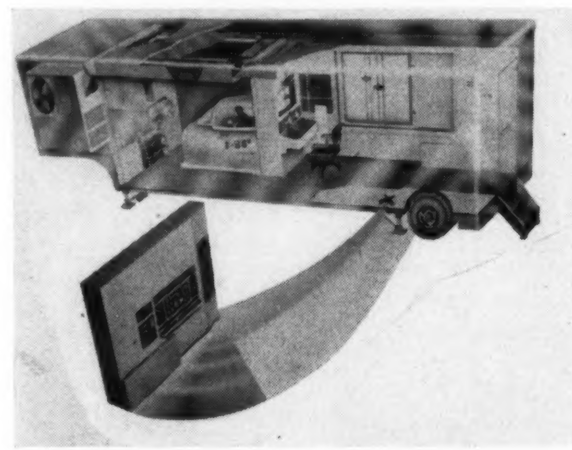
In addition to the quadrant detection, the equipment will detect and display an aircraft that comes within 800 feet in the hemisphere above or the hemisphere below the aircraft. This will be displayed to the pilot by lighted lamps that indicate whether the intruding aircraft is above or below the flight plane. The equipment will give additional warning if another aircraft enters the opposite hemisphere from the one displaying a warning. The indication will continue until the object either goes beyond the 800-foot radius or is within a minimum distance of 400 feet of the center of the aircraft, when the 400-foot warning lamp will light. This indication will continue until the object goes beyond 400 feet or is within a minimum distance of 200 feet. This minimum is necessary to prevent the indication of the aircraft's own wingtips or tail extremities. (*From* 24*-page issue of "Collin's Signal", Vol. V, No.* 4, *Collins Radio Co., Cedar Rapids, Iowa.*)

For this literature circle **104** on inquiry card.

Pilot Saver

Hurtling along at 600 miles per hour, the pilot shot a glance at the red warning light on his panel: his engine was on fire. He well realized he had only seconds to bring the fire under control—or to bail out. Working feverishly, he swiftly followed condition reflexes to localize the emergency. Then he cut his engine, removed his flight gear, and stepped out of the cockpit . . .

He stepped out onto the ground, next to his F-86-K Sabrejet electronic flight simulator. Another life saved . . . another plane worth a million and a half dollars preserved.



It costs the Air Force approximately $550 to keep a four engine transport plane in the air for one hour. But for $46 an hour, pilots can "fly" the very same plane right on the ground—and have the same experience they would receive in the air. At one Air Force training base over four million dollars a year of your tax money is saved by the use of electronic flight simulators.

By introducing a series of emergency conditions into a single training flight, the simulators develop conditioned reflexes in pilots and crews on a vastly accelerated schedule . . . Too, the real aircraft can be earning its keep in the air while more pilots are learning to fly it "on the ground."

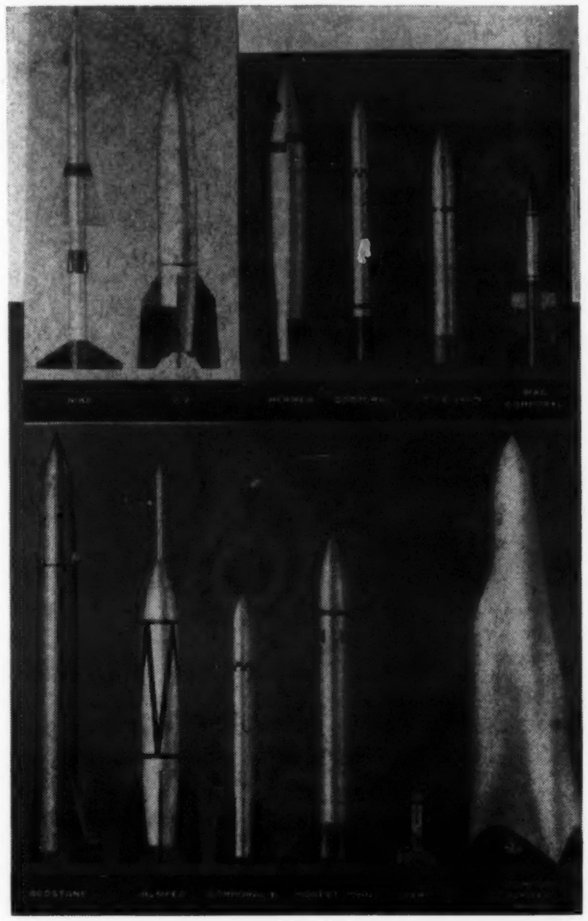
Simulators and trainers also provide instruction for air crewmen in the operation of radar, electronic countermeasures, magnetic anomaly detectors, sonar, sonobuoys, and armaments systems—the highly complex equipment which is the normal complement of today's aircraft. (*From* 36*-page issue of "Wheels", Vol.* 11, *No.* 8, *ACF Industries, Inc.*, 30 *Church St., New York* 8, *N.Y.*)

For this literature circle **105** on inquiry card.

Army Guided Missiles

Missiles are designated according to the jobs they perform. Surface-to-surface missiles are launched against targets on the earth's surface including enemy troop concentrations, factories and other installations of value to an aggressor. Surface-to-air missiles are launched against enemy aircraft. The anti-missile missile is a weapon for defense against other missiles.

1. Army surface-to-surface missiles now operational or soon to be operational include Corporal, Honest John, Little John, Lacrosse, Dart, Redstone and Jupiter.



2. Army surface-to-air missiles include Nike I and Nike B. An operational defense weapon, Nike is guarding against any airborne targets which might be encountered today or in the near future. Nike is generally dispersed around a number of important cities and industrial centers in this country.

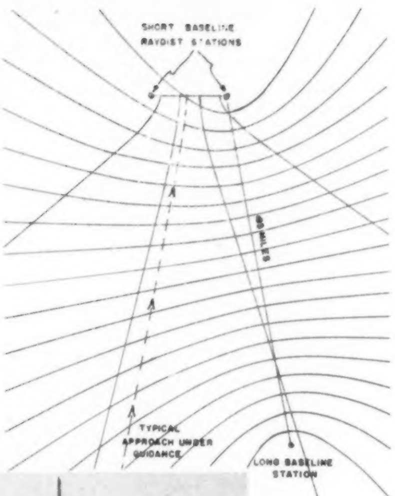
3. Today, Army Ordnance has underway an aggressive anti-missile program; hardware component development has been initiated on those components on which success of the system will depend. *(From new 20-page Bulletin 56SD182, Information Office—Marketing, Missile and Ordnance Systems Dept., General Electric Co.,* 3198 *Chestnut St., Phila.* 4, *Pa.)*

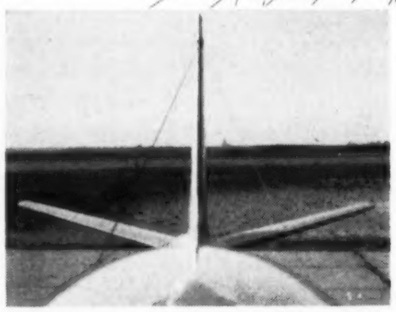
For this literature circle **106** on inquiry card.

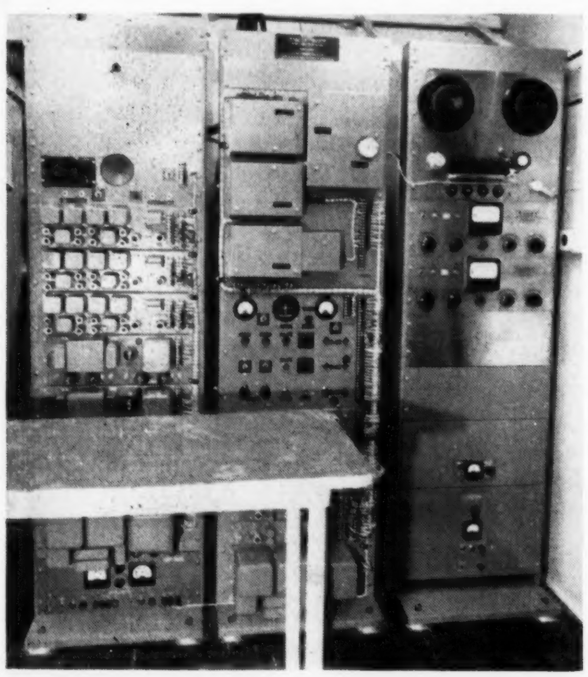
MA New Products

Jets Controlled in Time-Space

In this latest Raydist Airplane Guidance System, F-84 Fighters are controlled over a path of 200 miles so accurately in speed and track as to arrive within 250 ft. or less of the designated target position at the proper instant. This precision is achieved with an essentially automatic indication which is as simple as an ILS indicator for the pilot to follow. In the Raydist system two fixed receivers compare the phase change between a signal transmitted from the plane and a signal from a fixed ground transmitter. A short baseline between the two fixed receivers establishes a set of radial lines or "lanes" one of which would pass through any desired target point. Any deviation from this line produces a change in phase angle which is transmitted as an audio tone centered at 200 cycles over UHF radio to the plane. This signal is used to operate a left-right cross pointer indicator. By adding a third receiving station the position of the plane along its lane will be represented by continued phase changes in a set of "Progress" signals, and a comparison between this "progress" signal on one flight at a certain time after takeoff and the "progress" signal generated by a subsequent plane at the same position will show no difference. Accordingly each plane is "paced" against a "phantom craft" which consists of a precision tape recording of the phase signal from a previous "model" flight. The difference between the tape and the received signals is again transmitted as an audio modulation of a 1100 cps center-frequency to give a fast-slow indication which operates the horizontal pointer. Ampex Corporation engineers solved the very precise recording problem. The pilot only has to keep his "right-left" and the "fast-slow" cross pointers centered.







During training all pilots showed marked improvement during first runs. A Navy plane equipped only with a Raydist transmitter but having no indicating equipment was talked over the range with surprising accuracy by a pilot watching cross pointers at the master station. Several mobile stations can operate simultaneously from the one set of ground stations.

The new Plane-guidance system is the latest addition to the Raydist family of electronic navigational systems for aircraft and marine use. Highest accuracy at the long distances used, minimal use of electronic frequencies, wide area coverage, freedom from weather or atmospheric conditions, and high dependability with minimum equipment and personnel requirements are some of the previously claimed advantages of the Raydist system over radar or Loran systems of navigation. To these is now added precision in time-space control at jet-plane speeds. Also, the form in which the control data appears at the master station is most readily automated. This development might provide a technical break-thru which will go far in solving the growing air-traffic-control problem.—*Hastings-Raydist, Inc., Hampton, Va.*

For more information circle **201** on inquiry card.

TEMPERATURE CONTROLLER

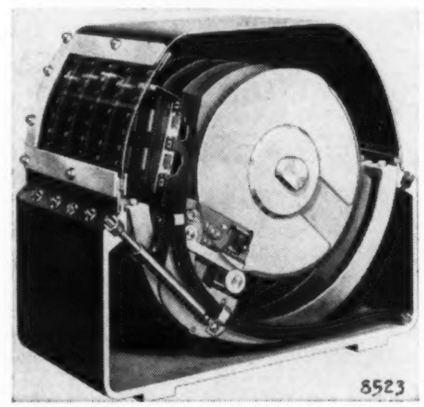
New "Type F56 Remote Bulb Temperature Control" is a wide-range uncalibrated skeleton unit designed for use in ovens, incubators, etc., where space or weight is a limiting factor. Basic components: control head with attached bellows, bulb, and capillary tube that connects bulb to bellows. Models of "Type F56" are available with a span of 200 F° between limits of −150°F and 150°F or 70°F and 370°F; or with a span of 500 F° between limits of 100°F and 650°F. On-off differential is about 1 F° or 2 F°.

Choice of switches: normally-open, normally-closed, or double-throw with no neutral position.—*United Electric Controls Co., 85 School St., Watertown, Mass.*

For more information circle **202** on inquiry card.

SEQUENCE CONTROLLER

New "Bulletin 102 Type AL Rotating Cam Limit Switch," for precise synchronization of multiple operations, has 15-amp contacts; features positive micrometer screw adjustment of each individual switch mechanism in relation to its cam. This adjustment can be made with a screwdriver, from outside, while switch is in motion. Made in three standard sizes accommodating up to five, nine, or twelve individually-adjustable cams. Contact assemblies can have two sets of contacts. Speed limit 100 rpm.—*Clark Controller Co., 1146 E. 152nd St., Cleveland 10, Ohio.*

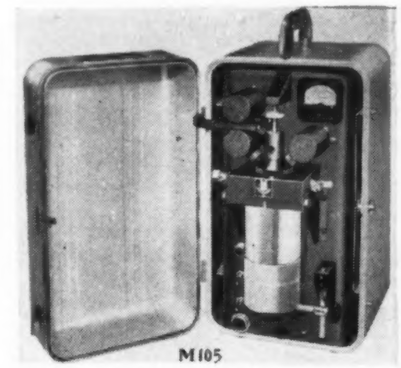


For more information circle **203** on inquiry card.

For more information on the manufacturers' products, circle number on inquiry card facing inside back cover.

ELECTRONIC HYGROMETER

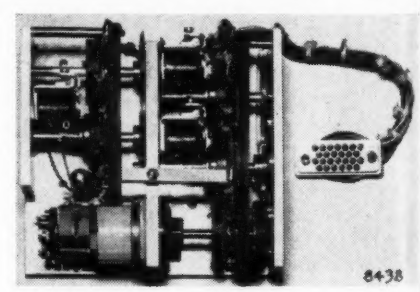
New "Model 901 Electronic Dew Point Hygrometer" weighs 24 lb, is for use as an air-borne instrument on 115-v 400-cps power; can be supplied for use on 115-v 60-cps for use in labs, wind tunnels or for control of industrial processes as well as meteorology. Dew-point temperature can be measured from −50°C to 18°C with accuracy of 1 C° at pressure of + or −½ atmosphere with sample flow rate of 500 to 2,000 cc/min. Principle: a first surface mirror is cooled by CO_2 acetone bath and heated by an induction coil. A light source, two photocells and an electronic system preserve balance between cooling and heating. Dew-point is read when thinnest observable dew forms upon mirror.—*Burton Mfg. Co., Santa Monica, Calif.*



For more information circle **204** on inquiry card.

PROGRAM CONTROLLER

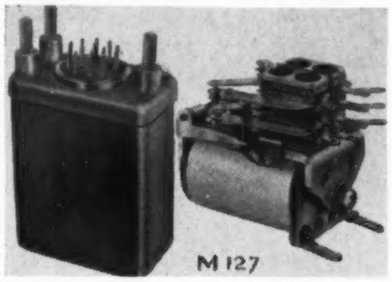
New Sequence Timer features six separately-operating wipers on five shafts, operating at different speeds: three are relay-actuated and three are constantly-rotating intervalometers. Relay-actuated wipers are connected to clutch plates kept from rotating by a relay-operated ratchet. When a pulse is received by relay, ratchet is pulled, thereby permitting clutch plate and wiper to make one revolution. Switches handle currents up to 6 amp at 28 vdc, will withstand 1000 v. Instrument will stand 20 *G* or higher. —*Motronics Corp., 241 Concord St., Glendale 3, Calif.*



For more information circle **205** on inquiry card.

MULTI-CONTACT RELAY

New "Type 9" miniature telephone-type multi-contact relay for aircraft, missiles, computers, etc., has features comparable to

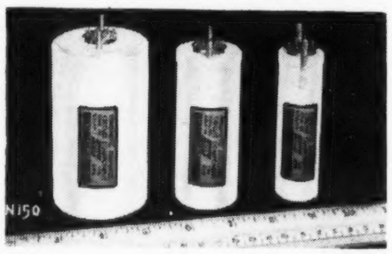


"Type 8"; measures $1\frac{5}{32}''$ long by $\frac{23}{32}''$ wide (height depends on number of springs); is also available as a hermetically sealed unit measuring $2\frac{1}{8}''$ x $1\frac{5}{8}''$ x 1" overall. Coil: dc only single or double wound; resistance up to 14,000 ohms; maximum dissipation 3 watts; contacts: forms A, B, C or D (AxB); wide choice of contact materials; maximum of 18 springs (9 per pile-up).—*Phillips Control Corp., Joliet, Illinois.*

For more information circle **206** on inquiry card.

MAG-AMP BUILDING BLOCKS

New "Maximag" magnetic amplifier circuit components can be used to assemble any of the well-known basic circuits for



fast response and high gain; are available in up to 300 watts capacity; meet MIL specs. Three basic sizes cover 1.5 to 300 watts, 60 and 400 cps. Largest unit (300 watts at 400 cps) measures only $4\frac{1}{16}''$ H by $2\frac{7}{16}''$ D.—*Adler Electronics, Inc., 1 LeFerve Lane, New Rochelle, N. Y.*

For more information circle **207** on inquiry card.

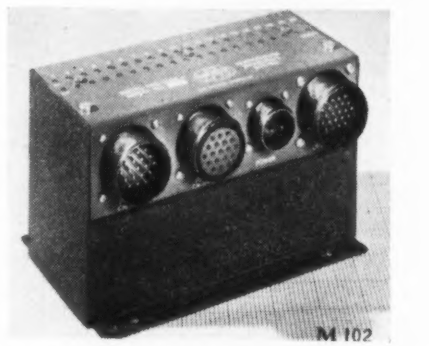
A-M RADIO RECEIVER AND CONELRAD MONITOR

New "Alert Monitor" is a low-cost AM radio receiver which, by the flick-of-a-switch, becomes an automatic warning device in case of an enemy air attack. Its dual function makes it ideally applicable for all transmitter operations required since January 2, 1957 to provide facilities for receiving CONELRAD alerts and for banks, schools, theaters, hotels, and other public gathering places as an advance warning system of an impending enemy attack. When switched to NORMAL position, new monitor is tunable to any radio station within range in AM broadcast band (540 to 1620 kc). In CONELRAD position, receiver is inaudible but becomes activated when a CONELRAD alert has been initiated. Designed for continuous operation, new monitor provides radio station operators with a reliable alert system which will not cause intermixed and confusing transmissions, or distractions from regular broadcast procedures. It weighs $4\frac{1}{2}$ lb; is 12" wide by 6" deep by 7" high.—*Mobile Communications Sales Dept., Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Ave., Clifton, N. J.*

For more information circle **208** on inquiry card.

THERMOMETRIC SYSTEM

New "TME" compact and rugged airborne multichannel temperature instrumentation system is designed to operate di-



rectly into airborne telemetering and magnetic tape systems, with maker's special resistance type primary elements (available in many types). Models are offered in 7-, 14- and 20-channel capacity. "TME" contains two precision mag-amp type regulated dc power supplies, series connected with common neutral, for excitation of resistance elements in half-bridge circuitry; balance and attenuation controls for each channel. System stability is within 1% throughout MIL-E5272A environment.—*Arnoux Corporation, 11924 West Washington Blvd., Los Angeles 66, California.*

For more informatio ncircle **209** on inquiry card.

PRESSURE PICKUPS

New pressure "Synchrotel Transmitters," for use in high-speed aircraft and guided missiles are lighter (weight about 1 lb),

more compact, and have far less internal static volume than previous Kollsman models. This smaller volume results in significantly better response time, whence higher dynamic accuracy, further aided by more precise calibration and better temperature compensation.—*Kollsman Instrument Corp., 80-08 45th Avenue, Elmhurst 73, N. Y.*

For more information circle **210** on inquiry card.

New Products—*Cont.*

SUBMINIATURE SERVOMOTOR

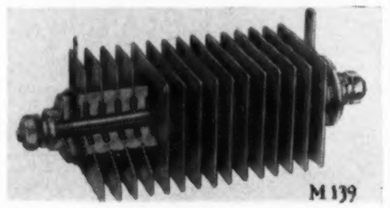
New "SM-58" said to be "smallest standard unit now available," weighs under 1 oz; features extremely high

torque to inertia ratio; operates on 26 v 400 cps with a control voltage range of 0-26. Typical characteristics include 2.5w input; 0.1w output; 0.063 oz-in stall torque; 8800 rpm no load speed; 0.00038 oz-in^2 rotor inertia; and 64,000 rad/sec^2 theoretical accelerations at stall; ambient range −75°F to 200°F.—*Component Sales, Ford Instrument Co., Div. of Sperry Rand Corp.,* 31-10 *Thomson Ave., L.I.C.* 1, *N.Y.*

For more information circle **211** on inquiry card.

POWER RECTIFIERS

New line of selenium power rectifiers is especially suitable for special applications such as lab and test pur-



poses, radiation detection equipment, magnetic amplifiers, electrostatic air cleaners and for guided missile applications. Rectifier cells range in size from 1" x 1" to 5" x 6" and with convection cooling are rated from 0.18 to 10 amp per cell on a single-phase full-wave bridge basis. Featured in new rectifier is "solid stack" assembly in which all mounted parts are under constant pressure provided by end springs, whence utmost rigidity and maximal protection against scrapping or chipping seal. To retain utmost rigidity, cells 4" x 4" and over are made with square mounting holes and are mounted on square tubing.—*Union Switch & Signal Div., Pittsburgh* 18, *Pa.*

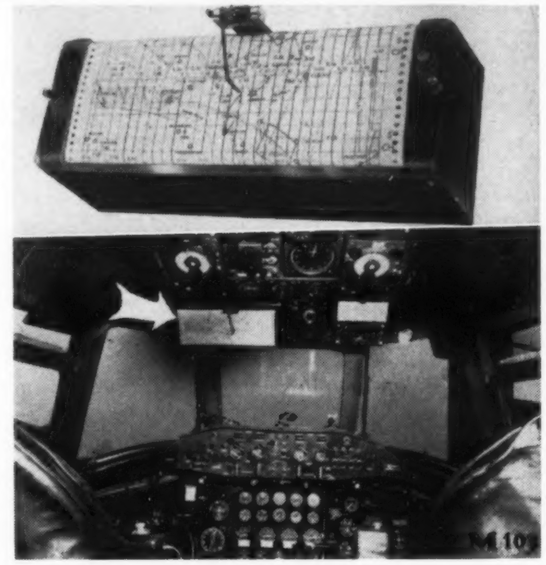
For more information circle **212** on inquiry card.

AIR NAVIGATION SYSTEM

New lightweight (150-lb) completely self-contained airborne electronic navigator eliminates manual navigation problems for pilots of jet fighters who, when operating at today's speeds and ranges, have little margin for navigational error; can also serve as a new navigational aid for longer-range aircraft, including commercial airliners. It does not depend upon any form of ground information or control; can navigate a plane between any two points on earth's surface; provides pilot at all times with an indication of his present position, along with course to fly and distance to destination. Before takeoff, pilot need only set into system the longitude and latitude coordinates of his departure point and his destination. Upon reaching his destination, or target, pilot need only set in new point of departure and destination coordinates for system to pilot his return course. Main components: a Doppler radar unit, an earth's rate directional heading reference unit, a miniaturized electronic computer, and pilot's indicators.—*Light Military Electronics Dept., General Electric Co., Syracuse, N. Y.*

For more information circle **214** on inquiry card.

Air Navigation System

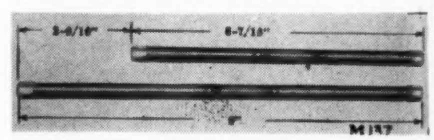


New "Bendix-Decca" is of area coverage type; operates on low-frequency radio waves (about 100 KC), thus is usable behind hills, in valleys, beyond line-or-sight and below curvature of earth. Good reception and high accuracy from ground level to highest altitudes make system "ideal for helicopter as well as fixed-wing use." System operates by transmissions from a master station and three slave stations, yielding a network pattern of hyperbolic waves which occupy precisely-known and stable geographic positions. Location of aircraft is automatically and instantaneously displayed on a chart by a moving ink stylus. Accuracy better than 25 yards under normal conditions at distances of up to 50 miles from transmitting stations. System is designed for short- and medium-range navigation. ★A similar system, called "Dectra," has also been developed for long-range use. A pilot, with one set of receiving equipment aboard his aircraft, could use the "Decca" after takeoff and during approach to his terminal area and "Dectra" while flying at his selected cruising altitude.—*Bendix Pacific Div., North Hollywood, Calif.*

For more information circle **213** on inquiry card.

SELENIUM RECTIFIERS

New "Selenium Slim" rectifiers feature higher reverse voltage rating per cell stamped from a new thinner base material, as compared to previous cell. New cell has a reverse voltage rating of 33 v rms and is about 20% thinner than previous cell. Selenium tubular rectifiers for high-voltage low-current

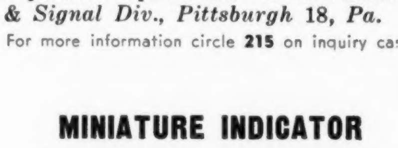


applications are available in physical cell sizes from ⅛" to ½" dia and are rated 1.25, 2.5, 5, 10 and 20 ma dc per cell, in half-wave circuit using a capacitor input filter—*Union Switch & Signal Div., Pittsburgh* 18, *Pa.*

For more information circle **215** on inquiry card.

MINIATURE INDICATOR

New "HCM 1¼" aircraft electrical indicating instrument features dual display in a case 1 9/32" OD by 2"



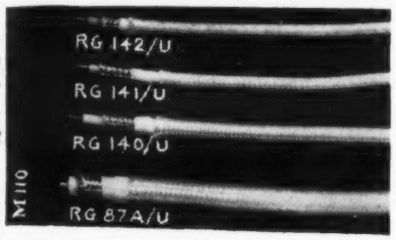
long; has application wherever two functions must be clearly displayed in minimal space, under severe temperature, shock and vibration conditions.

Mounting: AN 5808 type clamps. Available in all ranges normal to dc moving-coil instruments, weight 4 oz. —*Marion Electrical Instrument Co., Grenier Field, Manchester, N. H.*

For more information circle **216** on inquiry card.

HI-TEMP COAX CABLES

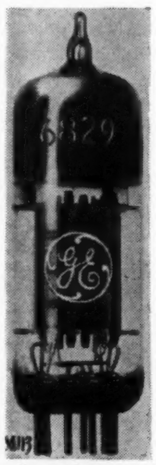
New extra-tough Teflon coaxial cables will operate successfully in enviromental temperatures from



−100°F to 500°F; are impervious to moisture and exhibit consistent electrical and physical properties over their entire operating range.—*Components Div., Federal Telephone and Radio Co.,* 100 *Kingsland Road, Clifton, N. J.*

For more information circle **217** on inquiry card.

TWIN TRIODE

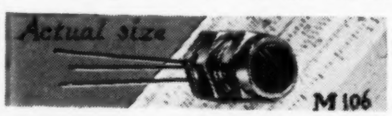


New "6829" 9-pin miniature medium-mu TT is first in a line of "5-Star" high-reliability computer tubes for services in severe environments in which airborne and mobile military computing equipment must operate. It has same electrical ratings as "5965." In addition, it must pass high reliability tests for stability, survival, heater-cycling shock and fatigue. Altitude rating 60,000 ft; impact acceleration 450 *G;* vibrational acceleration 2.5 *G.—Tube Dept., General Electric Co., Schnectady* 5, *N. Y.*

For more information circle **218** on inquiry card.

MINIMALIZED TRIMMER "POT"

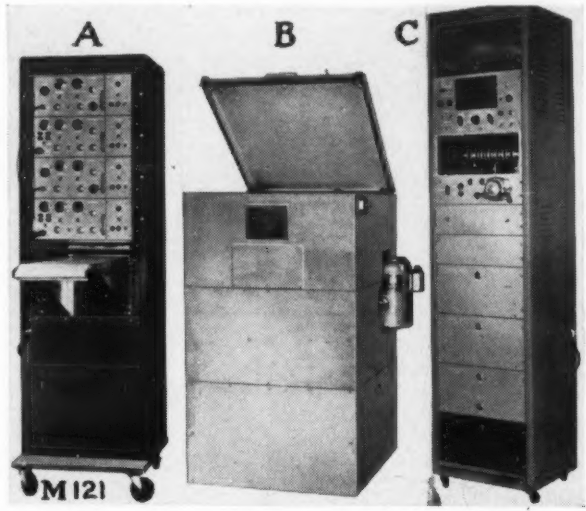
New "Type 101C Locking Bushing Potentiometer" is essentially a locking bushing with a voltage divider



built inside; is available in 16 standard resistance values from 47 ohms to 15,000 ohms, all manufactured with 20 ppm resistance wire. Contact resistance (equivalent noise resistance) is held to a tighter tolerance than ever before. Power dissipation is ¼ watt up to 95°C (derated to zero at 145°C) for 2,000 hours.—*Carter Mfg. Corp., Hudson, Mass.*

For more information circle **219** on inquiry card.

Rocket Flight Simulator



New automatic test system subjects acceleration-sensitive devices to entire range of acceleration and deceleration forces encountered during rocket and missile flights; duplicates any two-stage flight during each test. It comprises (A) data-recording unit, (B) acceleration-deceleration, unit and (C) program unit. Acceleration-deceleration unit contains a vector-seeking specimen mount which eliminates virtually all undesirable side accelerations. An acoustic specimen cavity and special microphone permits audio data sensing so that hermetically sealed units can be tested. Two energy-storing flywheels can accelerate a device from 2 to 125 *G* in 200 milliseconds; minimum braking time 100 milliseconds; maximum fight time 55 seconds. Program-unit controls test cycle.—*The Magnavox Co., Dept. N.P., Fort Wayne* 4, *Indiana.*

For more information circle **221** on inquiry card.

SERVO ACTUATOR

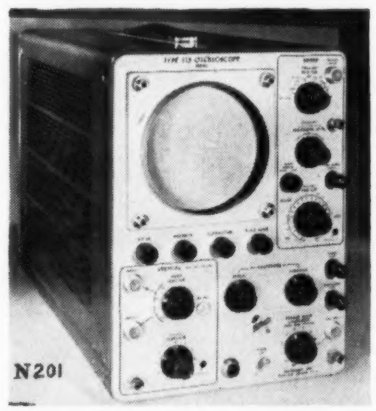
New "D-9" permanent-magnet type rotary servo actuator for airborne applications features high pow-

er/weight ratio; is designed for continuous operation at an output rating of 70 lb-in at 8.5 rpm. Theoretical acceleration at stall is 40,000 radian/sec² and dynamic motor braking is incorporated. Weight 1.9 lb; diameter 3$\frac{5}{16}$"; overall length 4⅞" including AN connector. Unit meets MIL-E-5272A and MIL-I-6181B.—*White-Rodgers Co.,* 4407 *Cook St., St. Louis* 13, *Mo.*

For more information circle **220** on inquiry card.

CATHODE-RAY OSCILLOSCOPE

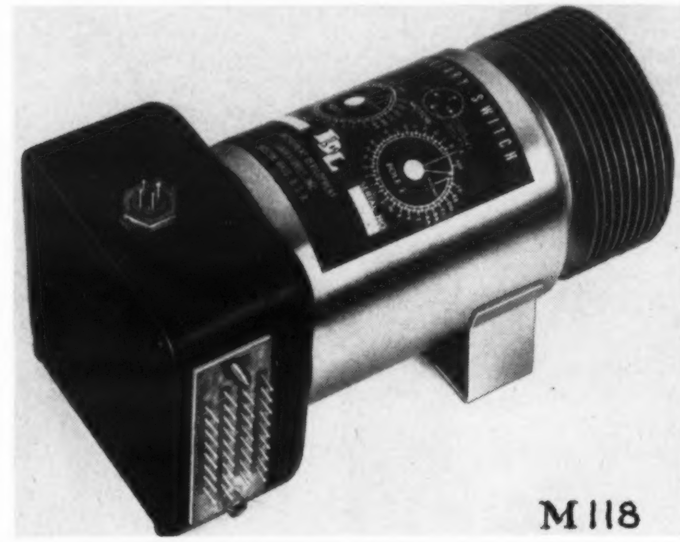
New "Type 515" is a 5" dc-coupled general-purpose lab instrument said to occupy less bench space and to have



wider application than many larger instruments. Passband is dc to 15 Mc, with 0.023-usec risetime; sensitivity is calibrated in 9 steps from 0.1 to 50 v/cm, continuously variable from 0.1 v/cm to 125 v/cm; 0.25-usec balanced delay network; 22 calibrated sweeps from 0.2 usec/cm to 2 sec/cm; 5× magnifier is accurate on all ranges, full sweep range 0.04 usec/cm to 6 sec/cm continuously variable; trigger amplitude-level selection or automatic triggering. Accelerating potential 4 kv.—*Tektronix, Inc., P. O. Box* 831, *Portland, Oregon.*

For more information circle **222** on inquiry card.

Telemetering Commutator

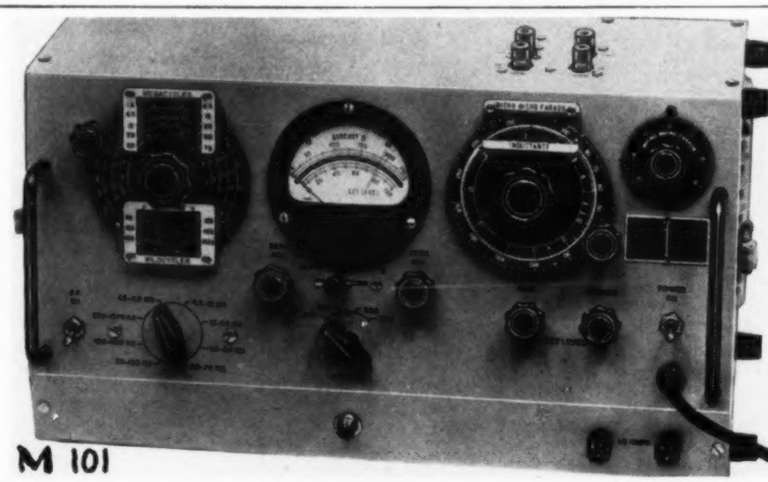


M118

New telemetering commutator with a life expectancy exceeding 500 hours without servicing is contained in a hermetically-sealed case to operate under military environments. Powered by a 115-v 400-cps two-phase motor, it requires 7 w to provide 10-rps pole speeds and 15 w for 30 rps. Interpole phasing accuracies of 0.2 millisecond can be maintained at 30 rps pole speeds. Contact resistances of less than 0.25 ohm are practically invariant and inter-contact impedances exceed 100 megohms during service life. Two-pole unit has exceeded 1000 hours life at 10 rps and has withstood 200 cps vibration frequencies at 16 *G* amplitude.—*Instrument Development Labs., Inc., 67 Mechanic St., Attleboro, Mass.*

For more information circle **223** on inquiry card.

Rugged Q Meter

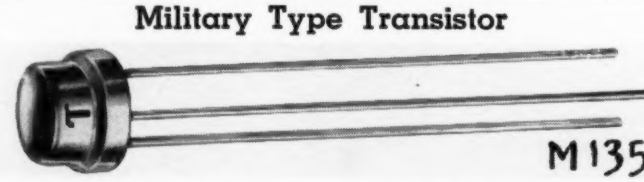


M 101

New "Model 162," designed to overcome objections in existing *Q* measuring instruments, can be used by inexperienced personnel without fear of damage. Other features are wider frequency range (50 kc to 75 Mc); internal regulation on both 110- and 220-v operation, a readily-monitored injection voltage of 20 mv, and use of a single easily-read indicator.—*Alpha Instrument Co., 43 Hempstead St., New London, Conn.*

For more information circle **224** on inquiry card.

Military Type Transistor



M135

New "2N200" germanium *p-n-p* junction transistor, designed for electronic equipment requiring extreme reliability at high temperatures and under severe environmental conditions, is rated and tested for operation up to 75°C; features welded hermetic sealing and 100% inspections for shock, vibration and moisture resistance; has a typical common emitter current gain of 45; can dissipate up to 350 mw; has low noise figure and low collector cut-off current.—*Transitron Electronic Corp., Melrose, 76, Mass.*

For more information circle **225** on inquiry card.

FUEL GAGE TESTER

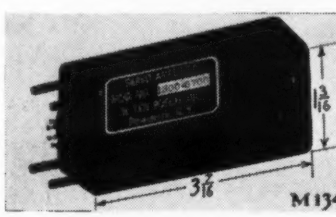
New "Type Md-2 Capacitor-type Fuel Quantity Gage Tank Unit Tester" meets AF Spec MIL-T-4687; com-

bines: (1) servo-operated self-balancing three-terminal capacitance bridge, to 5000 uuf in three ranges in increments as low as 0.1 uuf, accuracy better than 0.5% of full scale; (2) extremely accurate megohmmeter, to 10,000 megohms, on a log scale; is supplied with 9 accessory cables for connecting to all types of fuel gages. —*Telectro Industries Corp.*, 35-18 *37th St., Long Island City* 1, *N. Y.*

For more information circle **226** on inquiry card.

SERVO AMPLIFIER

New "Model 1800-0700" miniaturized (6-oz) hermetically-sealed plug-in transistor servo amplifier is pri-

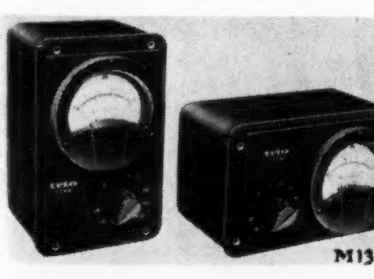


marily intended to receive signals from a synchro control transformer and to operate a size-15 60-cps 6.1 watt servomotor or equivalent; is designed to meet the environmental requirements of MIL-E-5400.—*M. Ten Bosch, Inc., Pleasantville, N. Y.*

For more information circle **227** on inquiry card.

RUGGEDIZED AC VTVM

New "Model SD152" miniature ac vacuum-tube voltmeters, designed exclusively for panel-mounting in mili-

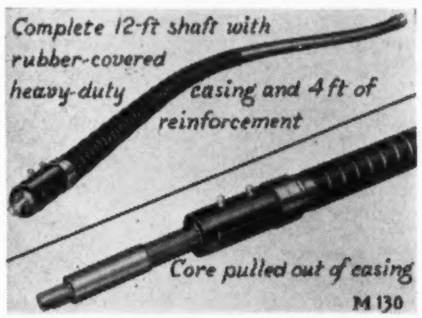


tary equipment, provide test equipment designers with greater flexibility in panel layout; meet appropriate military specs, including MIL-T-945A and MIL-E-5400; feature signal lead isolation from power circuit and case, enabling voltage measurement between any two independent test points; have a frequency response of 20-50,000 cps and an input impedance of 1 megohm.—*Trio Laboratories, Inc.*, 4025 *Merrick Road, Seaford, N. Y.*

For more information circle **228** on inquiry card.

POWER FLEXIBLE SHAFT

New shaft, said to be "strongest power drive flexible shaft in the world" features a new 1¼" dia.

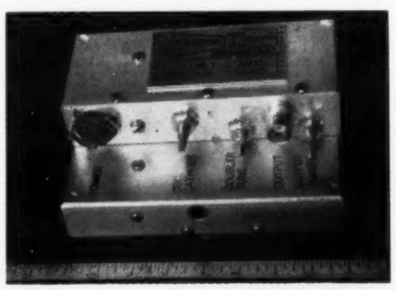


heavy-duty core made up of layers of tightly-wound high-grade music wire, with which new flexible shaft can transmit up to 1650 lb-in of torque at 440 rpm. Heavy duty flexible casing is lined with oil-tempered spring steel, reinforced with wire braid, covered with oil-resistant neoprene impregnated fabric and an abrasion-resistant rubber jacket.—*Stow Mfg. Co.*, 364 *Shear St., Binghampton, N. Y.*

For more information circle **229** on inquiry card.

SUB-MINIATURE TRANSMITTER

New Model 1472 PDM/FM or FM/FM Sub-miniature transmitter is designed especially for telemetering and guidance systems requiring the maximum in dependability. Said to be the first true FM telemetering trans-

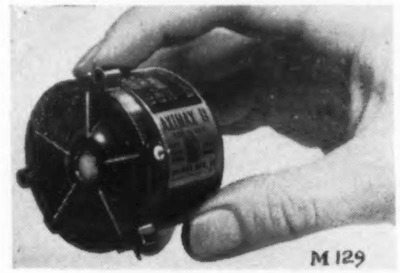


mitter, it features very rugged construction and unusual center frequency stability. Designed for operation in the 215-235 mc band, it delivers an output of 1.5 watt into a 50-ohm resistive load; 4" long, it weighs only 11 ounces; response is flat (3 db) from 100 cps to 80 kc.—*Telechrome Manufacturing Corp.*, 28 *Ranick Drive, Amityville, N. Y.*

For more information circle **230** on inquiry card.

VANEAXIAL FAN

New 4-oz "Aximax II" cooling fan is said to represent "a new landmark in miniaturization": motor is of in-



side-out construction whereby rotor and air-moving impeller are cast in one piece. Fan moves 58 cfm at free delivery and 35 cfm at 2" static pressure; runs at 20,000 rpm and is wound for 400 cps either 200 v 3 phase or 115 v 1 phase.—*Rotron Mfg. Co., Schoonmaker Lane, Woodstock, N. Y.*

For more information circle **231** on inquiry card.

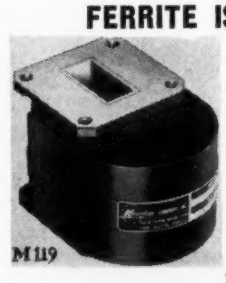
MINIATURE TRIMMING VDR

New "Aero Pots" are miniature trimming voltage-dividing resistors said to feature "unusual ruggedness,

stability and long life." Aluminum body and cover are both U-shaped, cover precision-fitted to body to resist warping and protect against humidity, splashing and dust. Units are adjustable throughout 32 turns by a screw-driver in a slotted shaft. Settings are stable under extreme vibration and shock. Resistances range from 100 ohms to 50,000 ohms in one case size. Temperature ranges: —55°C to 125° C.—*Aero Electronics Corp.*, 2311 *W. Burbank Blvd., Burbank, Calif.*

For more information circle **232** on inquiry card.

FERRITE ISOLATOR



New "Model W-167-1A" high-power displacement absorption ferrite isolator is rated at 200 kw peak and 300 w average. Isolation 17 db minimum; insertion loss 0.5 db maximum; VSWR about 1.1. Weight 18 oz; insertion length 1.75".—*Kearfott Co., Inc.*, (*Western Div.*), 253 *North Vinedo Ave., Pasadena, Calif.*

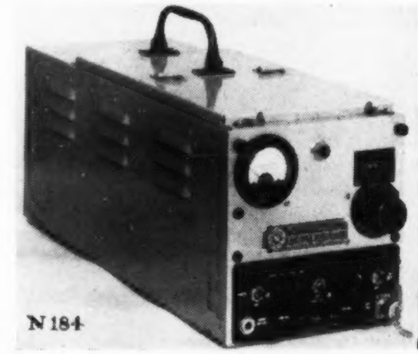
For more information circle **233** on inquiry card.

New switches specifically designed for aircraft use are designed for MIL environmental requirements. Capsular elements which operate snap-action switch have been specifically designed for this application, and assure utmost resistance to vibration. Over-pressure protection is provided also. Many mounting arrangements pressures between 5 and 150 psi, and "miniature" from 2 to 100 psi; each in absolute, gage, or differential as specified. Both types are regularly supplied in sp-dt snap-action type wired for N-O or N-C—*The Bristol Company, Waterbury 20, Conn.*

For more information circle **234** on inquiry card.

FREQUENCY METER

New "No. 7-18" measures frequency in 100-10,000-Mc range; consists of a heterodyne oscillator using a 2C40 triode with

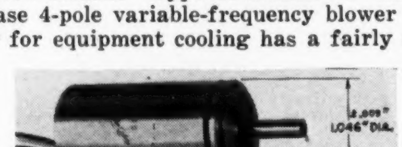


waveguide type tuning elements continuously tunable from 500 to 1250 Mc, a detector-mixer circuit, an audio amplifier, beat indicator and crystal calibrator circuit. Frequency is measured by zero-beating the signal (or one of its harmonics) against output of heterodyne oscillator (or one of its harmonics).—*Northeastern Engineering, Inc., Manchester, N. H.*

For more information circle **235** on inquiry card.

BLOWER MOTOR

New smaller "Type 11-A-8223-01" single-phase 4-pole variable-frequency blower motor for equipment cooling has a fairly con-

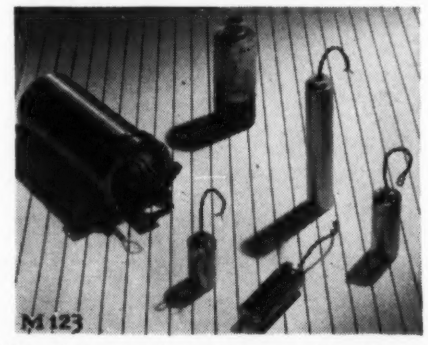


stant speed over a wide frequency range at 115-v excitation through use of two small external capacitors. Operating ambient temperature range −54°C to 70°C (higher upper-limit on special order).—*John Oster Mfg. Co., Avionic Div., Racine, Wis.*

For more information circle **236** on inquiry card.

UNITIZED GAS GENERATORS

New pre-packed gas generators provide power for operation of turbines, pressurization, actuation of pistons and expand-

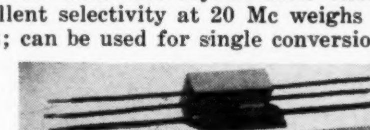


able rings, and ignition of liquid propellants. Squibs with electrical circuitry are included as integral parts of generators or as threaded-in sub assemblies. Units create known amounts of gas at predictable pressures and temperatures for given time periods. Horsepower outputs 0.01 to 150; output pressures 15 to 25,000 psi.—*McCormick Selph Associates, 103 Hollister Airport, Hollister, Calif.*

For more information circle **237** on inquiry card.

20-Mc CRYSTAL FILTER

New miniature crystal filter offering excellent selectivity at 20 Mc weighs about 1 oz; can be used for single conversions from

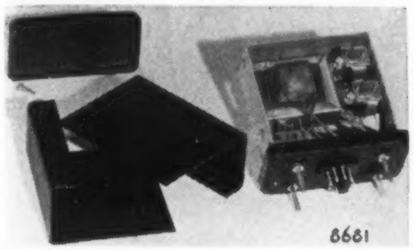


UHF or VHF in AM or FM receivers. Center frequency 20 Mc; bandwidth at 6 db attenuation 50 kc; shape factor=ratio of bandwidth at 60 db to bandwidth at 6 db=4/1; no spurious modes above 50 db; insertion loss 3 db max.—*Hycon Eastern, Inc., 75 Cambridge Parkway, Cambridge 42, Mass.*

For more information circle **238** on inquiry card.

CONTROL PACK

New miniaturized plug-in control pack contains all basic control circuitry needed for use with "meter-



relays" (contact-type automatic-control millivoltmeters). It measures about 4"x2"x4": one-fourth the space usually required for such circuitry. Many circuit variations are available, but standard minimum parts include an isolation transformer, a dc power supply (including rectifiers), and slave relays to provide 5-amp 115-vac contacts. Frequently an interrupter or sampling circuit is also included. Standard 11-pin octal type base; four mounting studs; completely dust-tight case permits quick access to parts and wires.—*Tipp-Tronic, Inc., Tipp City, Ohio.*

For more information circle **239** on inquiry card.

2-WAY MOBILE RADIO

New "MCA-110-B" vibrator-powered unit offers 60 to 75 watts across its entire frequency band of 25 to 54 Mc. Designed for use with either 6- or 12-v systems, it features deviation-compensated "squelch," and a simple flick-of-the switch selector for one-to-four channel operation. A single compact casing houses transmitter, receiver, power supply, and all relays (weight 55 lbs). High stability is achieved through use of high-precision low-drift crystals obviating need for evens.—*Mobile Communications Sales Dept., Allen B. Du Mont Labs, Inc., 760 Bloomfield Ave., Clifton, N. J.*

For more information circle **240** on inquiry card.

DRONE SYSTEM

New aerial drone system, for evaluating performance of photographic and television cameras in droned surveillance missions, consists of an L-17 aircraft modified for photo-television-drone operation; a unique auto-pilot which provides effective remote control of the drone by means of on-off type radio signals, and a rugged ground control station which can be transported in a jeep. Modified L-17 can be used as a ground-operated pilotless aircraft, or go aloft with a safety pilot. When drone's mission is completed, ground controller flicks an "approach" switch which automatically positions landing gear, flaps, prop pitch and power in proper sequence for landing. Then he directs aircraft onto runway.—*Temco Aircraft Corp., P.O. Box 6191, Dallas, Texas.*

For more information circle **241** on inquiry card.

For more information circle **31** on inquiry card.

OTHER NEW PRODUCTS OF NOTE

New 3-Minute size-23 synchros provide over twice accuracy specified in FXS 1066, Mil-S—16892 (BuOrd); in some instances obviate synchro systems for aircraft.
Norden-Ketay Corp. .... Circle **242**

New XKDT-1 low-cost missile target operates at sonic speeds—is launched from carrier-based aircraft.
Temco Aircraft Corp. .... Circle **243**

New Data Display and Transfer Indicators (for Air-Flight-Plans information) store, readout or transfer over 1000 words per minute.
Union Switch and Signal ...... Circle **244**

New high permeability Fernetic shield protects microwaveguides, tubes, and ferrite isolators from magnetic fields.
Perfection Mica Co. .... Circle **245**

New Type-S hi-temp film-type high-precision glass resistors meet Mil-R-11804B specs.
Corning Glass Works .... Circle **246**

New "Type 5602-02" size-18 low-speed high-torque motor-gear-train with unusually great output for its size can be operated in temperatures as low as −55°C.
John Oster Mfg. Co. .... Circle **247**

New "1100 Series EASE" analog computers combine a digital output-input translator system (DO/IT) with other new features designed for automatic operation and high accuracy.
Berkeley Div., Beckman Insts., Inc. .... Circle **248**

New "Model 75" keyboard accessory for maker's 11"x17" X-Y recorders comprises a 10-key keyboard and a rack-mounted program and memory unit.
Electro Instruments, Inc. ...... Circle **249**

New "Azimuth Alignment Theodolite", permits alignment of precision gyroscopes to 2 seconds of arc.
Perkin-Elmer Corp. .... Circle **250**

New "Model 253-E" low-cost panel indicating instrument will withstand punishment more rigorous than standard military 1200 foot-pound shock test.
Assembly Products, Inc. .... Circle **251**

New "1101 Converter" comprises essentially a rectifier, vibrator and filter network; accepts any 115-v power between 50 and 400 cps and converts it to requirements of servo analyzer.
Servo Corp. of America .... Circle **252**

For more information circle **29** on inquiry card.

MA New Literature

ELECTRONIC INSTRUMENTS

BEAT FREQUENCY OSCILLATOR. New 28-page issue of "Bruel & Kjaer Technical Review" (November 1956), presents articles on a new beat frequency oscillator, automatic output regulator of beat frequency oscillator, and combined units.—Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio.
Circle **301** on inquiry card.

GALVANOMETERS. New 12-page Bulletin 1528 describes and illustrates applications of maker's "Series 7-300" galvanometers and accessories.—Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.
Circle **302** on inquiry card.

TUBE TESTER. New 2-page Bulletin CR5-290 describes maker's "Videochek Model CR5" TV picture-tube tester.—Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, Ohio.
Circle **303** on inquiry card.

TESTING INSTRUMENT. New 2-page Bulletin describes maker's analyzer "141-A" used for testing Brown Electronik continuous balance amplifier units.—Parameters, Inc., 195 Herricks Rd., Garden City Park, New Hyde Park Post Office, N. Y.
Circle **304** on inquiry card.

TEST EQUIPMENT CALIBRATOR. New 2-page Bulletin pictures and describes maker's "Model 750" electric-test-equipment calibrator.—B & K Mfg. Co., 3726 N. Southport Ave., Chicago 13, Ill.
Circle **305** on inquiry card.

MINIATURE VOLTMETERS. New 2-page data sheet No. 239 presents description of maker's miniature ac voltmeter line with expanded scale.—International Instruments, Inc., P. O. Box 2954, New Haven 15, Conn.
Circle **306** on inquiry card.

FREQUENCY COUNTER. New 4-page issue of "Hewlett-Packard Journal" (Vol. 7, No. 11-12) features article on new "A 0-1.1 MC Frequency Counter with Time Interval Markers".—Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.
Circle **307** on inquiry card.

IMPEDANCE METERS. New 2-page data sheet describes maker's coaxial and waveguide impedance meters.—Narda Corp., 160 Herricks Rd., Mineola, L. I., N. Y.
Circle **308** on inquiry card.

ANALYZERS. New 4-page Catalog Digest describes makers' instruments designed for applications requiring accurate high speed frequency or waveform analysis.—Panoramic Radio Products, Inc., 9 South Second Ave., Mt. Vernon, N. Y.
Circle **309** on inquiry card.

MICRO-MICROAMMETERS. New 2-page Data Sheet E-03-1 describes maker's micro-microammeters for nuclear reactor control systems.—Leeds & Northrup Co., 4907 Stenton Ave., Phila. 44, Pa.
Circle **310** on inquiry card.

OSCILLOSCOPE. New 8-page brochure provides information and data on maker's "Type 515" wide-band oscilloscope.—Tektronix, Inc., P. O. Box 831, Portland 7, Oregon.
Circle **311** on inquiry card.

TEST EQUIPMENT. New 12-page illustrated bulletin pictures and describes maker's waveguide and coaxial test equipment.—Admittance-Namco Corp., Farmingdale, L. I., N. Y.
Circle **312** on inquiry card.

TUBE ANALYZER. New 2-page bulletin describes maker's Thyratron and "Phanotron" tube analyzer.—Alectric Mfg. Co., 7842-39th Ave., Kenosha, Wis.
Circle **313** on inquiry card.

FREQUENCY METER. New set of 2-page Data Sheets furnishes specs, operation data, and uses of Type 504 Precision Heterodyne Frequency Meter; Standing Wave Detector, Type 219; and Klystron Power Supply, Type 809.—Polytechnic Research & Development Co., Inc., 209 Tillary St., Brooklyn 1, N. Y.
Circle **314** on inquiry card.

JET ENGINE INSTRUMENTATION. New 20-page brochure presents company's testing equipment and production facilities for jet engine control components.—Manning, Maxwell & Moore, Inc., Aircraft Products Div., Danbury, Conn.
Circle **315** on inquiry card.

PROTOTYPE FACILITIES. New 6-page bulletin outlines company's services and manufacturing facilities for making prototype turbine engine components.—Saffran Engineering Co., 20225 E. Nine Mile Rd., St. Clair Shores, Mich.
Circle **316** on inquiry card.

DC AMPLIFIER. New 4-page Bulletin CH374 describes and illustrates Hilger-Negretti d-c amplifier, an ultra sensitive, zero-drift galvanometer amplifier for measurement of extremely low currents and potentials.—Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.
Circle **317** on inquiry card.

AUTOTRANSFORMER. New 24-page Bulletin O describes maker's "Variac" adjustable autotransformers.—General Radio Co., Cambridge 29, Mass.
Circle **318** on inquiry card.

SIGNAL GENERATOR. New 6-page bulletin presents specifications of maker's "Model SG-132" precision VHF-UHF signal generator and accessories.—Transitron, Inc., 186 Granite St., Manchester, N. H.
Circle **319** on inquiry card.

FREQUENCY CONVERTER. Three new 4-page Bulletins (176-12-56, 184-12-56, 185-12-56) presents information and data on maker's "Model 275" intermediate frequency converter; "Model 95" standard FM signal generator; and "Model 505" standard test set for transistors.—Measurements Corp., Boonton, N. J.
Circle **320** on inquiry card.

AUDIO OSCILLATOR. New 2-page Bulletin 8549 describes and illustrates maker's "Audiolator" all-transistorized beat frequency audio oscillator, powered by mercury or penlight cell batteries.—Kay Electric Co., 14 Maple Ave., Pine Brook, N. J.
Circle **321** on inquiry card.

ELECTRONIC INSTRUMENTS. New 48-page brochure presents data on maker's electronic instruments, controls, power supplies, etc.—Deltron, Inc., 2905 N. Leithgow St., Philadelphia 33, Pa.

Circle **322** on inquiry card.

ELECTRON MICROSCOPE. New 12-page Brochure RC178 discusses construction and operation of maker's electron microscope and covers descriptions of all its components.—North American Philips Co., Inc., Instruments Div., 750 South Fulton Ave., Mt. Vernon, N. Y.

Circle **323** on inquiry card.

RECORDERS

RECTILINEAR RECORDER. New 10-page Bulletin R-501 contains all important information on maker's rectilinear recorder and accessories changing curvilinear motion to true rectilinear motion.—Houston Technical Laboratories, 3609 Buffalo Speedway, Houston 6, Tex.

Circle **324** on inquiry card.

OSCILLOGRAPH. New 4-page illustrated bulletin provides information and data on maker's "Type 401" low-frequency oscillograph and "Type 404" pulse-generator.—Allen B. DuMont Labs., Inc., Clifton, N. J.

Circle **325** on inquiry card.

TAPE RECORDER. New 26-page Bulletin 1561B describes and illustrates maker's multi-channel magnetic tape recording and playback system for recording stress, pressure, temperature and vibration.—Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle **326** on inquiry card.

TAPE RECORDER. New 20-page Bulletin FR100 contains all information on maker's "FR100" instrumentation tape recorders used in data acquisition, storage, analysis and reduction, etc.—Ampex Corp., Instrumentation Div., 934 Charter St., Redwood City, Calif.

Circle **327** on inquiry card.

OSCILLOGRAPHS. New 2-page Bulletin 1536B presents two new explosion-proof modifications for maker's "Type 5-119" recording oscillograph.—Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle **328** on inquiry card.

COMPUTER ACCESSORY EQUIPMENT. Three new 2-page leaflets and a 4-page folder (Series 1-000) describes maker's servos, resolvers, recorders, "Model 108" three-channel instrument signal converter, etc.—Dynalysis Development Laboratories, Inc., 11941 Wilshire Blvd., Los Angeles 25, Calif.

Circle **329** on inquiry card.

POTENTIOMETERS, RESISTORS

PRECISION POTENTIOMETERS. New 2-page Data Sheet 54-18 shows construction of maker's series B precision potentiometers, and gives specifications and characteristics.—Helipot Corp., a division of Beckman Instruments, Inc., Newport Beach, Calif.

Circle **330** on inquiry card.

COMPOSITION RESISTORS. New 12-page Bulletin B-1A presents specifications, characteristics-charts, etc. of maker's "Type BT" fixed composition resistors.—International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

Circle **331** on inquiry card.

HIGH FREQUENCY RESISTORS. New 8-page Bulletin F-1a discusses types MP and HFR frequency & miniature high frequency resistors, including data on construction, characteristics, applications, types, resistance values, etc.—International Resistance Co., 401 N. Broad St., Phila. 8, Pa.

Circle **332** on inquiry card.

RESISTORS, RHEOSTATS. New 4-page Bulletin 53 contains ratings for fixed and adjustable vitreous enameled resistors and rheostats.—Hardwick, Hindle, Inc., 40 Hermon St., Newark 5, N. J.

Circle **333** on inquiry card.

RESISTORS AND SNAP SWITCHES. New 32-page Bulletin RC-10B describes maker's variable composition resistors and snap switches. Includes dimensional drawings.—Stackpole Carbon Co., St. Marys, Pa.

Circle **334** on inquiry card.

POTENTIOMETERS. New 2-page Technical Data Sheet 102 presents specifications on maker's minimalized trimmer potentiometers.—Carter Mfg. Corp., 23 Washington St., Hudson, Mass.

Circle **335** on inquiry card.

POWER SUPPLIES

POWER SUPPLY. New 2-page Bulletin 1570 describes and illustrates maker's "Type 3131" 26-volt d-c power supply.—Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle **336** on inquiry card.

POWER SUPPLIES. New 4-page Catalog 568 gives information on maker's voltage-regulated power supplies for transistors, strain gages, etc.—Kepco Laboratories, Inc., 131-38 Sanford Ave., Flushing 55, N. Y.

Circle **337** on inquiry card.

BATTERIES. New 8-page brochure describes maker's "Sturges" nonspill storage batteries and cells.—Electronic Batteries, Inc., Bush Terminal Bldg., No. 4, 28-34 35th St., Brooklyn 32, N. Y.

Circle **338** on inquiry card.

CUSTOM POWER SUPPLIES. New 18-page brochure shows examples of company's custom power-supply designs, including the following types: Magnetic-amplifier-regulated; transistorized; transistor-driven-mag-amp; dc to dc; saturable-reactor controlled; etc.—NJE Corp., 345 Carnegie Ave., Kenilworth, N. J.

Circle **339** on inquiry card.

TUBES, TRANSISTORS

ELECTRON TUBES. New 4-page catalog presents list of maker's transmitting and industrial tubes for radio, industrial, and scientific uses.—BNC Industrial, 180 Spring St., Paterson 3, N. J.

Circle **340** on inquiry card.

SELENIUM RECTIFIERS. New 12-page Booklet 1007-10M pictures and describes maker's "Selenium Slims" union selenium power rectifiers.—Union Switch & Signal Div., Westinghouse Air Brake Co., Pittsburgh 18, Pa.

Circle **341** on inquiry card.

SILICON RECTIFIERS. New 26-page Booklet ECG-148A gives full information on maker's Series 4JA60 small high-current silicon rectifiers.—General Electric Co., Semiconductor Products, Electronics Park, Syracuse, N. Y.

Circle **342** on inquiry card.

NEW LITERATURE

TRANSISTOR RECTIFIERS. Three new 4-page bulletins (TE 1336, 1336A, 1338 and 1340) present data, and describe maker's military-type silicon power rectifiers and transistors, also germanium and silicon diodes. Two new 2-page leaflets give characteristics and data of lead mounted and miniature-type silicon rectifiers.—Transitron Electronic Corp., Melrose 76, Mass.

Circle **343** on inquiry card.

SELENIUM RECTIFIERS. New 16-page Bulletin 1009 presents maker's selenium rectifiers with design ratings, coding, and ordering information, etc.—General Apparatus Sales, Union Switch & Signal Div., Westinghouse Air Brake Co., Pittsburgh 18, Pa.

Circle **344** on inquiry card.

TRANSISTOR TEST EQUIPMENT. New 8-page Catalog 9-30-56 contains all information on maker's transistor test equipment, transistor power supplies, miniaturized components, constant current generators, etc.—Electronic Research Associates, Inc., 67-69 E. Centre St., Nutley, N. J.

Circle **345** on inquiry card.

SILICON-JUNCTION RECTIFIER. New 2-page Bulletin ECG-134A presents specifications and ratings of maker's silicon junction rectifier.—General Electric Co., Electronics Park, Syracuse 1, N. Y.

Circle **346** on inquiry card.

JUNCTION TRANSISTOR. New 2-page Specification Bulletin G-3 describes maker's germanium P-N-P alloyed junction transistor for low frequencies.—General Transistor Corp., 130-11 90th Ave., Richmond Hill 18, N. Y.

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RADAR TUBES. New DuMont sheet presents maker's Radar Tubes which save space and weight permitting full use of miniaturization techniques in airborne and other portable radar receivers.—DuMont Labs., Inc., 2 Main Ave., Passaic, N. J.

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CAMERAS

DATA RECORDING CAMERAS. New 8-page Brochure MC-2 describes maker's "Multidata," multi-purpose precision data recording cameras for automatic synchronized motion picture or single frame operation.—Flight Research, Inc., P. O. Box 1-F, Richmond 1, Va.

Circle **349** on inquiry card.

AERIAL PHOTOGRAPHIC EQUIPMENT. New 74-page Catalog 464 describes available aerial photographic and photo instrumentation equipment, and facilities for repair of all standard military photographic equipment.—Gordon Enterprises, 5362 N. Cahuenga Blvd., N. Hollywood, Calif.

Circle **350** on inquiry card.

DATA RECORDING CAMERAS. New 40-page brochure provides data on maker's high-speed and data recording 16mm and 35mm cameras for military and industrial use.—Traid Corp., 4515-17 Sepulveda Blvd., Sherman Oaks, Calif.

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CAMERAS. Seven new 2-page Data Sheets (7123, 7124, 7125, 7126, 7127, 7129, 7133) describes Bell & Howell "200-P" 16-mm magazine pulse camera; "198" portable splicers; "70-KRM" 16-mm motion picture camera; "71-QM, 71-KM, 71-MM, 71-RM," 35-mm motion picture cameras.—Traid Corp., 4515-17 Sepulveda Blvd., Sherman Oaks, Calif.

Circle **352** on inquiry card.

PHOTO EQUIPMENT. New 104-page Catalog 956M presents list of maker's adapters, camera backs, exposure meters, projection screens, shutters, etc.—Burke & James, Inc., 321 So. Wabash Ave., Chicago 4, Ill.

Circle **353** on inquiry card.

ITV

ITV. New 64-page booklet presents wide selection of video, audio, lighting, etc. equipment for ITV and includes 15-page guide to types and accessories for particular applications, maintenance, etc.—Graybar Electric Co., Inc., 420 Lexington Ave., New York 17, N. Y.

Circle **354** on inquiry card.

CLOSED-CIRCUIT TV. New 28-page RCA High-Fidelity Television guidebook presents maker's line of color and black-and-white closed-circuit television systems.—Radio Corporation of America, 30 Rockefeller Plaza, New York 20, N. Y.

Circle **355** on inquiry card.

INDUSTRIAL TV. New illustrated catalog presents maker's line of TV distribution units, installation accessories and closed-circuit TV equipment.—Blonder-Tongue Labs., 525-536 North Ave., Westfield, N. J.

Circle **356** on inquiry card.

CAMERA TUBES. New 16-page booklet (ETD-1192) illustrates how GE's Power Tube Sub-Dept. has established extensive facilities for the manufacture of image orthicons, vidicons and other pick-up tubes for military and commercial applications.—General Electric, Tube Dept., Schenectady 5, N. Y.

Circle **357** on inquiry card.

MOTORS, SERVOS

SERVOMECHANISM COMPONENTS. New 2-page Bulletin 410 describes maker's high-temperature servo mechanism components.—Norden-Ketay Corp., Commerce Rd., Stamford, Conn.

Circle **358** on inquiry card.

SYNCHROS. New 4-page Bulletin 409 presents specifications of maker's 3 minute, Size 23 synchros.—Norden-Ketay Corp., Western Div., 13210 Crenshaw Blvd., Gardena, Calif.

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GEAR MOTORS. New 8-page Bulletin GEA-6133A presents data on maker's fractional horsepower gear motors.—General Electric Co., Schenectady 5, N. Y.

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MOTORS. New 2-page bulletin describes maker's "Type FC" ac 400 cycle motors which can be wound either 3-phase, 2-pole or 4-pole; or 2-phase, 2-pole or 6-pole.—Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio.

Circle **361** on inquiry card.

SERVO UNIT. New 2-page bulletin describes maker's "BuOrd Size 10" miniature motor-gearhead-clutch.—Servomechanisms, Inc., Mechatrol Div., 625 Main St., Westbury, L. I., N. Y.
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SERVO MOTORS. New 4-page bulletin presents specs for low-inertia servo motors.—Bekey Electric Co., Inc., 1327 S. Main St., Los Angeles 15, Calif.
Circle **363** on inquiry card.

GEAR MOTORS, COUNTERS. New 12-page brochure describes maker's fractional horse power shaded pole gear motors and counters.—Electro Counter & Motor Co., 1713 N. Ashland Ave., Chicago 22, Ill.
Circle **364** on inquiry card.

SERVO AMPLIFIERS. Two new 2-page bulletins present maker's line of servo amplifiers for 60 and 400 cps servo motors.—Industrial Control Co., Wyandanch, L. I., N. Y.
Circle **365** on inquiry card.

TELESYN SYNCHROS. New 12-page brochure describes and illustrates maker's standard line of size 1, 3 and 5 Telesyn synchros.—Ford Instrument Co., Div. of Sperry Rand Corp., 31-10 Thomson Ave., Long Island City 1, N. Y.
Circle **366** on inquiry card.

INFRARED

INFRARED WEAPONS. New 4-page issue of new periodical "Around the Servo Circuit" (Vol. 1, No. 1) presents new developments in infrared weapons systems.—Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, L.I., N. Y.
Circle **367** on inquiry card.

THERMAL CONDUCTIVITY ANALYZER. New 12-page Catalog 56-1008-59 describes and illustrates applications and features of maker's "Condu-Therm" analyzer and "Acratron" electronic recorder.—The Hays Corp., Michigan City, Ind.
Circle **368** on inquiry card.

THERMOPILES. New 12-page Brochure CH 313/5 describes Hilger-Schwarz Thermopiles for conversion of infrared energy into electrical energy.—Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.
Circle **369** on inquiry card.

DATA PROCESSING

COMPUTING SYSTEM. New 9-page Form LSC-56,000 is an operational guide to new Univac Scientific 1103A electronic computing system; contains terminology list of instruction repertoire, and a keyed block diagram.—Remington Rand Univac Div. of Sperry Rand Corp., 1902 W. Minnehaha Ave., St. Paul, Minn.
Circle **370** on inquiry card.

STATIC CONTROL SYSTEM. New 8-page Bulletin GEA-6578 defines the fundamentals and features of general-purpose static control system for machine functions; lists advantages, and describes its logic elements.—General Electric Co., Schenectady 5, N. Y.
Circle **371** on inquiry card.

DATA PROCESSING. New 16-page Bulletin 32-6967 presents case studies of production control with random access memory and punched card, special industry bulletins describe applications in various specialized departments.—International Business Machines Corp., 590 Madison Ave., New York 22, N. Y.
Circle **372** on inquiry card.

DATA PROCESSING SYSTEM. New 4-page publication "Data For Decision" provides a complete description, specifications and applications of the new "ALWAC 800" electronic processing system.—Logistics Research, Inc., 141 So. Pacific Ave., Redondo Beach, Calif.
Circle **373** on inquiry card.

TAPE HANDLING EQUIPMENT. New 6-page brochure illustrates and describes a complete tape handling and storage system—reel trucks, files and storaways with stationary and portable racks.—TAB Products Co. of N. Y., 154 Nassau St., New York 38, N. Y.
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TAPE CONTROL SYSTEM. New 8-page Bulletin describes maker's punched-tape control system for automatic control of production machines.—Bendix Aviation Corp., Res. Labs. Div., 4855 Fourth Ave., Detroit 1, Mich.
Circle **375** on inquiry card.

COMPUTER. New 4-page Application Data Report 1H-106 presents typical industrial situation resolved by G-15D general-purpose computer.—Bendix Computer Div., Bendix Aviation Corp., 5630 Arbor Vitae St., Los Angeles 45, Calif.
Circle **376** on inquiry card.

DELAY LINES. New 16-page brochure presents specifications, definitions and measurements of maker's delay lines for computer and radar systems.—ESC Corp., 534 Bergen Blvd., Palisades Park, N. J.
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CUSTOM DESIGNED EQUIPMENT. New 2-page Data Sheet shows maker's Doppler Data Translator and describes the device and its application.—Potter Instrument Co., Inc., 115 Cutter Mill Rd., Great Neck, N. Y.
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LOGARITHMIC CONVERTER. New 4-page bulletin describes maker's "Model 60" converter for dc or ac input voltages with output voltages proportional to logarithm of the amplitude of the input voltage.—F. L. Moseley Co., 409 N. Fair Oaks Ave., Pasadena 3, Calif.
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COMPUTING

DIGITAL COMPUTER. New 6-page illustrated Bulletin AB116 provides information and data on maker's G-15D digital computer.—Bendix Computer Div., Bendix Aviation Corp., 5630 Arbor Vitae St., Los Angeles 45, Calif.
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ANALOG COMPUTER. New 16-page catalog describes maker's d-c analog computers and allied equipment.—Mid-Century Instrumatic Corp., 611 Broadway, New York 12, N. Y.
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COMPUTER SERVICES. New Cook Research Newsletter, Vol. No. 6, Issue 2, lists the digital and analog equipment contained in their expanded computer facility service.—Cook Electric Co., 2700 No. Southport Ave., Chicago 14, Ill.
Circle **382** on inquiry card.

ELECTRONIC COMPONENTS

COMPONENTS AND ACCESSORIES. New 20-page Bulletin presents list of maker's knobs and spiral lacing, pulse transformers, test probes, viewing accessories, color filters, etc.—Allen B. DuMont Labs., Inc., 760 Bloomfield Ave., Clifton, N. J.
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TUBULAR CAPACITORS. New 8-page Bulletin GET-2671 lists ratings and dimensions for maker's molded "PVZ" tubular capacitors.—General Electric Co., Schenectady 5, N. Y.
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CERAMIC CAPACITORS. New 20-page Catalog No. 616 specifies maker's Tiny-MIKE ceramic capacitors, including new temperature-compensating "Type C".—Cornell-Dubilier Electric Corp., South Plainfield, N. J.
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TRANSFORMERS, FILTERS. New 47-page Catalog 571 presents list of maker's audio transformers, discriminators, filters, power components, etc.—Freed Transformer Co., Inc., 1718-1736 Weirfield St., Brooklyn (Ridgewood 27, N. Y.
Circle **386** on inquiry card.

ELECTRONIC PRODUCTS. New 20-page Catalog No. 51 presents maker's new narrow neck disc cathode and new cathode material Cathaloy P-51, tubular electronics parts, cathode nickel alloys, glass sealing alloys, alloys for fabricated tubular parts, etc.—Superior Tube Co., 1566 Germantown Ave., Norristown, Pa.
Circle **387** on inquiry card.

SLIP RINGS. New 16-page brochure covers maker's slip rings, slip ring assemblies, microwave assemblies, and contact parts made from either laminated flat stock or raised lay.—D. E. Makepiece Co., Div. of Union Plate and Wire Co., Attleboro, Mass.
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TRANSFORMER. New 2-page Bulletin presents specifications on maker's miniaturized transistor transformer.—New England Transformer Co., Somerville, Mass.
Circle **389** on inquiry card.

TUBE CAP CONNECTORS. New 22-page handbook presents designs and specifications on maker's tube cap connectors for airborne and missile equipment.—Alden Products Co., Main St., Brockton, Mass.
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SWITCHES, RELAYS

SWITCHES. New 32-page Manual GEA 6372 furnishes compelte operation and application data for maker's manual, magnetic, and reduced-voltage starters; push buttons; relays; pressure and vacuum switches; float switches; solenoids; pressure governors etc.—General Electric Co., Schenectady 5, N. Y.
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RELAYS. New 4-page brochure provides information on maker's a-c and d-c miniature relays for airborne electronics etc.—Union Switch & Signal Div., Westinghouse Air Brake Co., Pittsburgh 18, Pa.
Circle **392** on inquiry card.

MICRO SWITCHES. New 4-page issue of "Uses Unlimited" (Vol. 10, No. 3) contains information on new developments in company's line of micro switches.—2-page Data Sheet 115 describes Type 1RA1 subminiature screw driver-actuated switch.—Micro Switch, a division of Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle **393** on inquiry card.

SWITCHES. New 4-page Catalog 200 illustrates and describes maker's push button, lever, and turn switches.—Donald P. Mossman, Inc., Brewster, N. Y.

Circle **394** on inquiry card.

PRECISION SWITCHES. New Haydon Switch-Idea File Catalog No. 5 provides data on maker's precision switches for aircraft, industry, and commercial application including subminiature switches.—Haydon Switch Inc., Waterbury, Conn.

Circle **395** on inquiry card.

HIGH TEMPERATURE

HIGH-TEMPERATURE WIRES. New 2-page Bulletin No. 1906 describes a series of single-conductor, 600-v, high-temperature aircraft hook-up wires designed to meet MIL-W-7139.—Revere Corp. of America, Wallingford, Conn.

Circle **396** on inquiry card.

OVER-HEAT DETECTORS. New 4-page MC-134 describes maker's thermistor-actuated over-heat detectors for temperature control and overheat detection in aircraft. —Fenwal, Inc., Aviation Products Div., Ashland, Mass.

Circle **397** on inquiry card.

MISCELLANEOUS

WAVEGUIDE COMPONENTS. New 20-page Catalog 5-6A presents maker's microwave test equipment and waveguide components.—Lieco, Inc., 3610 Oceanside Rd., Oceanside, L. I., N. Y.

Circle **398** on inquiry card.

MECHANICAL COMPONENTS. New 4-page bulletin presents ideas, techniques and designs of maker's mechanical components used for mounting, housing, fastening of electronic equipment.—Alden Products Co., 127 N. Main St., Brockton, Mass.

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LUBRICATION EQUIPMENT. New 2-page Product Data Sheet No. 5-55 presents Lear-Romec Engine Lubrication Equipment (Model RG-15530) for gas turbine engines built for ambient temperatures minus 65° to plus 350°F.—Lear, Inc., Lear-Romec Div., Elyria, Ohio.

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JET ENGINE HARNESS. New 4-page illustrated Bulletin MC-141 describes maker's jet engine harnesses and interchangeable thermocouples.—Fenwal, Inc., Ashland, Mass.

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HUMIDITY CONTROLLERS. New 4-page bulletin illustrates and gives pertinent data on "Serdex" indicating, recording and/or controlling humidity instruments.—Gardner Laboratory Inc., P. O. Box 5728, Bethesda 14, Md.

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For further details concerning developments reported in advertisements, or New Product or New Literature reviews, CIRCLE THE NUMBER corresponding to that which appears with the ad or write-up. If the card has already been used, mark the number on a postal card (including month of issue) and send to us. When indicating change of address, kindly note old address.

BREADBOARD PARTS. New 8-page issue of "Helinews" No. 15 (November 1956), describes maker's standard electromechanical breadboard parts, linear scale ac ammeter and "Duodial" turns-counting dial.—Helipot Technical Information Service Corp., Div. of Beckman Insts., Inc., Newport Beach, Calif.

Circle **403** on inquiry card.

HEATER CONTROLS. New 4-page brochure presents maker's line of aircraft heater controls.—Fenwal, Inc., Ashland, Mass.

Circle **404** on inquiry card.

TEMPERATURE CONTROLS. New 6-page Brochure MC-132 describes maker's complete line of miniaturized accessory temperature controls for aircraft, airborne equipment, guided missiles and ground apparatus.—Fenwal, Inc., Ashland, Mass.

Circle **405** on inquiry card.

FUEL PUMPS. New 2-page Data Sheet 3-21 presents maker's "Model RD-15240" electric-driven small-bore low-flow heater fuel pumps.—Lear, Inc., Lear-Romec Div., Elyria, Ohio.

Circle **406** on inquiry card.

PRESSURE RATIO INDICATORS. New 4-page Bulletin 361 describes maker's pressure ratio (engine discharge to inlet) indicating system for turbo-jet engines.—Instruments & Systems Div., Norden-Ketay Corp., Wiley St., Milford, Conn.

Circle **407** on inquiry card.

WIRE AND CABLE TIES. New 8-page Brochure B 80-200 presents maker's preformed "Guy-Grips", and splints and ties for wire and cable.—Preformed Line Products Co., 5349 St. Clair Ave., Cleveland 3, Ohio.

Circle **408** on inquiry card.

HEAT AND FLUID PROCESSING. New 12-page issue "High Gradient" (Nov.-Dec., 1956, No. 28) discusses improvements in solving heat and fluid processing problems.—Selas Corp. of America, Dresher, Pa.

Circle **409** on inquiry card.

MOBILE ELECTRONIC SYSTEMS. New 8-page brochure describes maker's mobile, transportable, and stationary electronic systems for communications and navigation.—New 4-page bulletin describes a lightweight shelter intended for helicopter transportation for emergency setup.—New 6-page booklet describes transit cases offering protection for electronic components, instruments and other fragile equipment during transportation and field use.—Craig Systems, Inc., Danvers, Mass.

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ULTRASONIC CLEANER. New 4-page Bulleting GW 45 contains all information on maker's "Model GW-5 and GW-4" ultrasonic instrument bearing and small parts cleaners.—The Baker Co., Inc., Maplewood, Maine.

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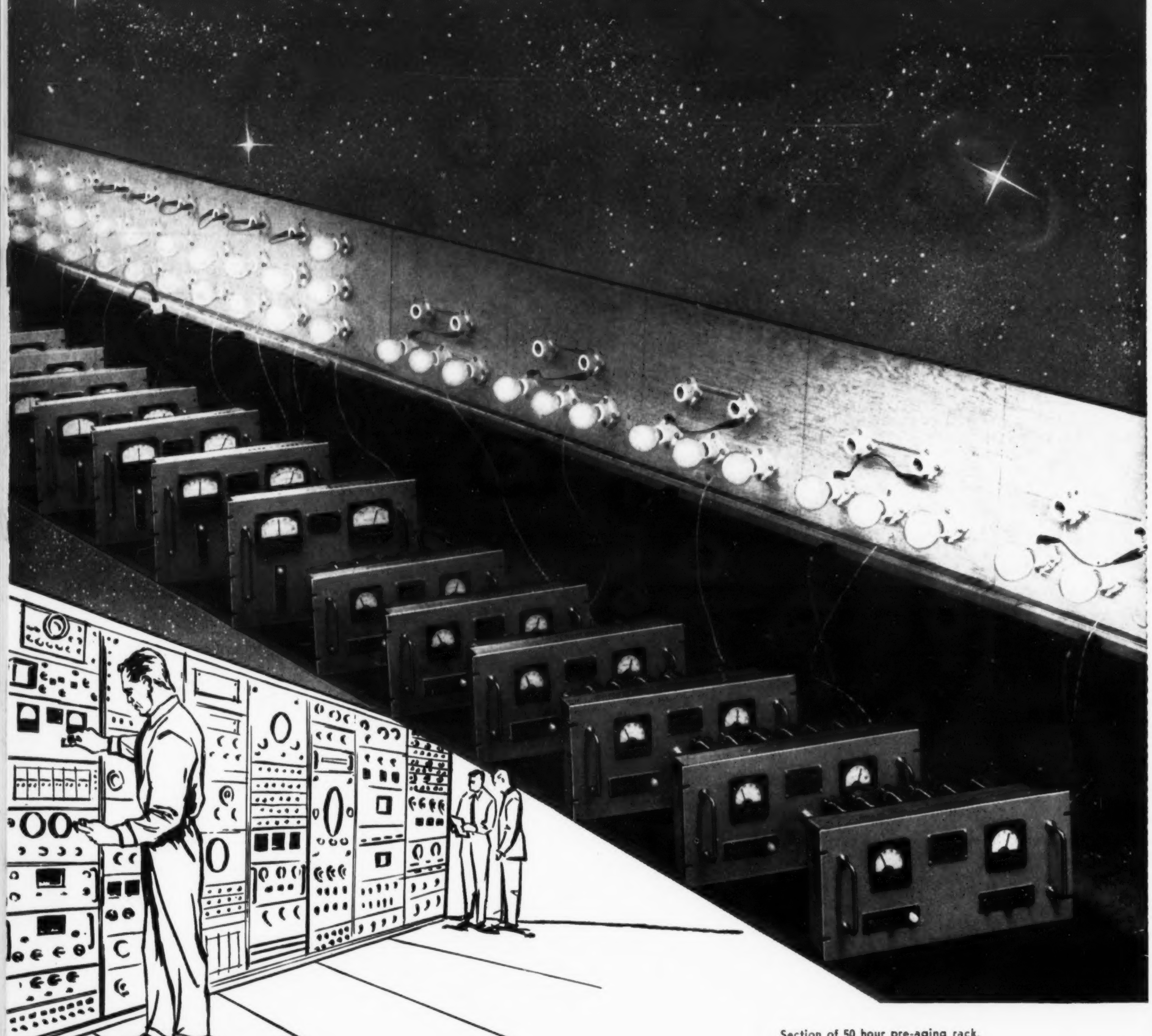

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